BBC

Science Focus
MAGAZINE
COLLECTION

THE SCIENTIFIC GUIDE TO A HEALTHY BODY & BRAIN

The best stress busters

How to have a happy brain

The truth about superfoods

Do brain-training games really work?

How VR, saunas and sleep can get you fitter

Is fasting good for you?

Supercharge your brain

Why it's good to be lazy

How to get the perfect night's sleep

What you need to feed your gut bacteria

Beat it

This photo of a cardiomyocyte cell, taken by graduate student Abigail Neininger and Dr Dylan Burnette at Vanderbilt University, was an image of distinction in the Nikon Small World photo competition. These cells are located in heart muscle, and the visible strands are fibres called sarcomeres. Each contains filaments of actin and myosin proteins, which work together to contract the cardiomyocytes, causing the heart to beat.

Neininger used a toxin called phalloidin to stain the cell and reveal its structure. The team hopes to discover how sarcomeres form, so they can one day rebuild cells that have been damaged by disease. "Cardiomyopathies, diseases of the heart muscle, affect sarcomeres," says Neininger. "If we understand how those contractile systems form in the first place, we might be able to understand more about those diseases."

ABIGAIL NEININGER/NIKON

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Health hacks

January is when I tend to think most about my health. That's not to say I ignore it the rest of the time; it's just that the overindulgences of Christmas and New Year force the subject to the front of my mind... for a short while at least, usually as long as it takes to come up with some resolutions.

While I don't think I'm in particularly bad shape, there's probably some room for improvement. And it would seem I'm not alone: according to the Health Survey for England, published in 2018, almost 90 per cent of the 8,000 adults surveyed had at least one lifestyle factor that was putting their health at risk, whether it be smoking, alcohol consumption, inactivity, obesity, or low fruit and veg consumption. More worryingly, just over half of them had between two and five of those risk factors.

And it's not just our physical health – the Mental Health Foundation revealed that 74 per cent of the 4,600 UK adults surveyed in early 2018 said that at some point in the previous 12 months stress had left them feeling overwhelmed or unable to cope.

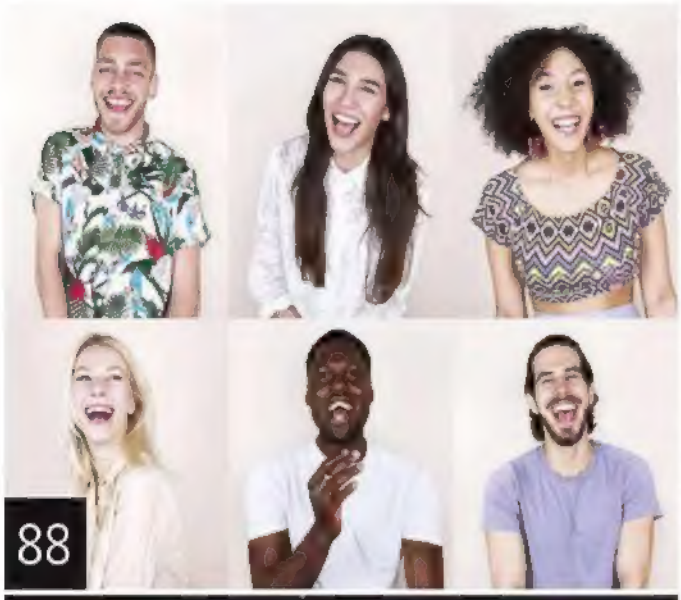
Given those stats, it's fair to say that health – either physical or mental – is a concern for all of us. What's encouraging, however, is that most of us already have a pretty good idea of what's required to maintain our general wellbeing: a varied and balanced diet, regular exercise, plenty of fresh air, contact with friends and family, a good night's sleep and the occasional glass of red wine (maybe).

What this guide sets out to do is put a scientific spin on that advice. By delving into the finer points of exactly what happens to your body and brain when you do (or don't) follow those guidelines, we'll explain how you can increase your chances of enjoying a healthy and happy 2020.

Daniel Bennett

Daniel Bennett, Editor

CONTEN



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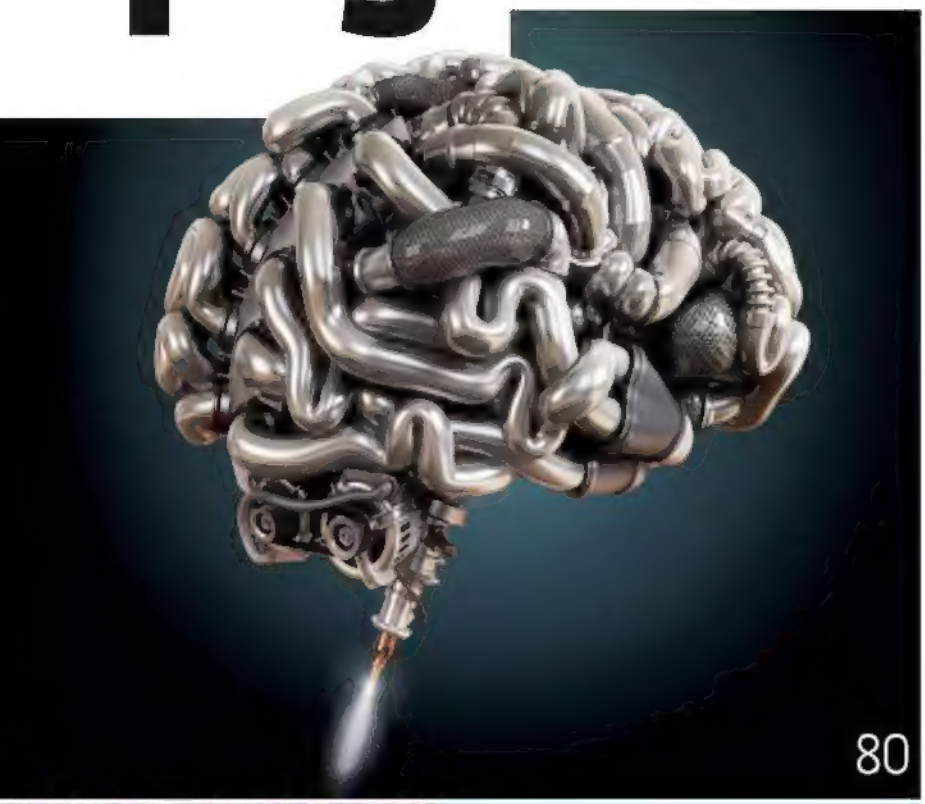
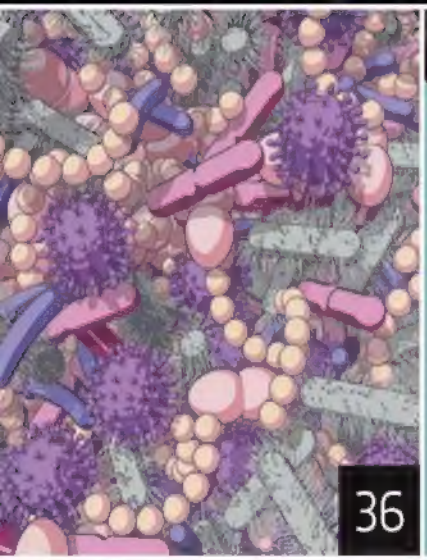
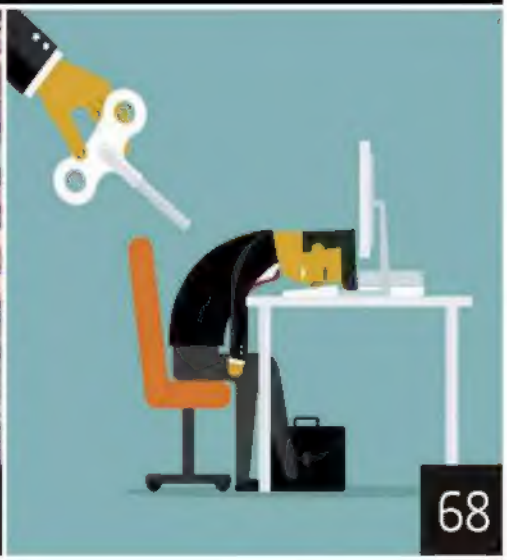






50 TIPS TO BOOST YOUR HEALTH

SOMETIMES IT'S THE LITTLE THINGS THAT MAKE ALL THE DIFFERENCE. HERE ARE SOME SMALL WAYS YOU CAN HELP TO KEEP YOUR BRAIN SHARP, GET SOME GOOD SHUT-EYE, AND STAY HEALTHY AND HAPPY

1 TRY YOGA

A study at Boston University found that attending yoga sessions twice a week can produce a significant decrease in symptoms in people suffering from major depressive disorders.

Another study, carried out by researchers at the University of Waterloo found that practising yoga for 25 minutes a day can boost brain function and the ability to control negative actions. The effect is thought to be due to the release of endorphins and increased blood flow in the brain.

DID YOU KNOW?

Consuming two portions of sugar-sweetened drinks a week increases the risk of developing diabetes.

2 MOVE OUT OF THE CITY

Mental decline occurs much more slowly among those living in villages than among urban dwellers, a 10-year study carried out in Barcelona has found. Reduced stress, lower pollution levels and more active lifestyles are believed to be factors.

3 DON'T GO BACK FOR A SECOND SLICE OF CAKE

Too many calories of any kind will lead to obesity, which increases your chance of developing diabetes. But a 2013 study found that adding 150 calories of sugar a day to your diet increases your risk of developing diabetes by 1 per cent, even after accounting for obesity, physical activity and total calorie intake. So sugar calories are especially bad.

GETTY IMAGES X4

4 GET MARRIED TO BE HAPPIER

Keele University carried out a meta-analysis of studies and found that married couples have a lower risk of heart disease and stroke than single, divorced or widowed people. The effect may be due to the enhanced wellbeing of having a partner. Researchers at the London School of Economics also found that having a partner boosts our happiness three times more than doubling our salaries.

5 AVOID INTERRUPTIONS TO YOUR SLEEP

Interrupted sleep is worse for you than losing sleep. At least, that's what one recent study shows. We've long known that sleep deprivation makes people bad tempered and miserable, and that insomnia is linked to depression, but exactly why is less certain. When volunteers slept in a lab and reported their mood every day, some were made to go to bed later than usual while others had their sleep interrupted several times. Both groups had the same total amount of sleep but the interrupted sleepers reported worse changes in mood. The researchers concluded that a lack of slow-wave sleep, which is the deepest type of sleep, was to blame.

So if your sleep cycle is disturbed at random times, disrupting your normal sleep pattern, try to find ways to remove those disturbances. There may not be much you can do about a crying baby waking you up in the night but, if your partner is a snorer, maybe give earplugs a go.

6 BUY EXPERIENCES, NOT MATERIAL POSSESSIONS

Studies show that people get more happiness from buying experiences than from purchasing material things. This is because experiences are more likely to bring us together with other people, whereas material things tend to be enjoyed alone. Research carried out by the College of Business at Stony Brook University, New York, found that a solitary experience made no more difference to a person's happiness than purchasing a physical item.

IN NUMBERS

2016

THE YEAR JUNK FOOD ADVERTS AIMED AT KIDS WERE BANNED IN THE UK

DID YOU KNOW?

16-19°C IS THE IDEAL TEMPERATURE FOR A GOOD NIGHT'S SLEEP IF YOU'RE WEARING PYJAMAS.

GETTY IMAGES X7

8 SPREAD YOUR BUTTER THINLY

For decades, we've been advised to reduce the amount of saturated fats, such as butter, in our diets, based on the argument that it increases bad cholesterol in the blood, which can clog arteries, causing heart attacks or strokes.

But a review of published data by researchers at the University of Cambridge in 2014 found there was no significant evidence regarding a correlation between saturated fats and a higher risk for heart disease. Hence the 'butter is back' headlines that subsequently appeared.

But those behind the study warned against over-simplification. They had found that there are different types of saturated fats that do different things – some good, some bad. While some dairy products might turn out to cut disease risk, that thought wasn't extended to butter. The team agreed with butter being linked to bad cholesterol.

7 ENJOY A STEAK NOW AND THEN (BUT AVOID BACON)

If you believe the headlines, then eating red meat will stop your heart, give you cancer, shorten your life and destroy the planet. But a paper entitled 'Meat Consumption And Mortality' came to the – perhaps surprising – conclusion that eating moderate amounts of red meat had no effect on mortality; in fact, it seemed to be protective. The lowest overall mortality rates in this study were among those people eating up to 80g a day, not those who shunned it. They concluded that "a low – but not a zero – consumption of meat might be beneficial for health... meat is an important source of nutrients, such as protein, iron, zinc, several B-vitamins, as well as vitamin A and essential fatty acids".

But the study also found that eating processed meat, such as sausages, bacon and ham, has a negative effect on health. Less than two slices of bacon a day increases the risk of death from cancer or heart disease.

9 BE POSITIVE TO STAY HEALTHY

Maintaining positive thoughts and feelings can reduce your risk of cardiovascular diseases, according to researchers at Northwestern University in the US. Their study found that optimistic people are more likely to take exercise, eat healthily and not smoke or be stressed.

10 TRY A LOW-CALORIE DIET

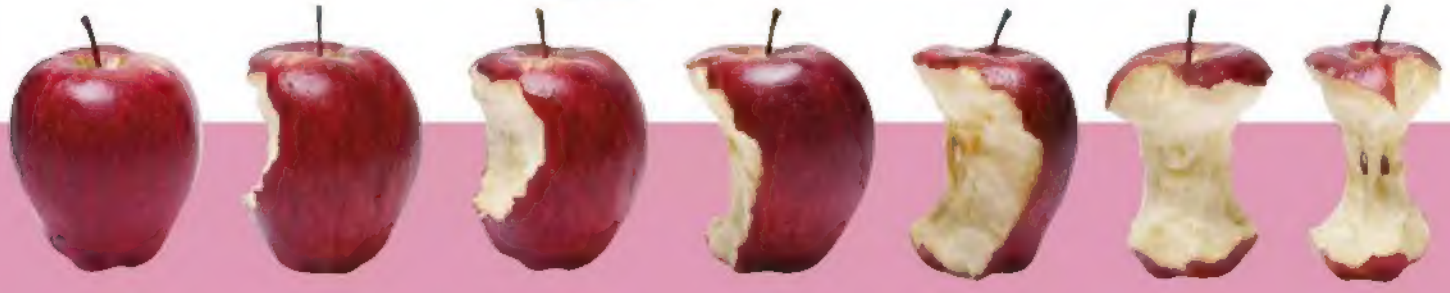
You might assume that supervised diet programmes, like the Cambridge Weight Plan, LighterLife and Optifast diets would be condemned by scientists as unhealthy and gimmicky. But research is finding that these very low-calorie diets are effective and safe if applied correctly. These diet programmes tend to consist entirely of pre-prepared snack bars, shakes and other food products. A major analysis of trials in 2016, headed by Birmingham University's Centre for Obesity Research, showed that these diets brought an average weight loss of 10kg after 12 months. This compares with research showing that behavioural programmes (focused on changing eating habits and exercising), such as Slimming World and Weight Watchers, bring a weight loss of 4kg after one year.

12 ELIMINATE UNNECESSARY PURCHASES

When contemplating a new purchase, apply the Tuesday Test: consider how it will affect the way you spend your time next Tuesday. Research shows that this simple thought exercise eliminates our tendency to overestimate how much any one thing will affect our happiness. Thinking about how purchases will affect your daily life turns decisions about money into decisions about time. This shift comes with a hidden bonus: focusing on time, rather than money, pushes people towards happier activities. In a study conducted at a café in Philadelphia, researchers asked people to think about time or money. Those with money on their minds ended up working more while at the café, whereas those prompted to think about time devoted more of their stay to socialising, one of the happiest activities in most people's days.

13 STOCK UP ON CHICKEN SOUP

There is some evidence that chicken soup can help if you have a cold. Several studies have found that something in chicken soup interferes with the ability of white blood cells to flock to the source of an infection. So chicken soup may help to relieve the inflammation of your throat and sinuses caused by white blood cells.



11 EAT 7 APPLES A DAY

Plenty of studies show that people who eat fruit tend to be healthier than those who don't, and that fruit eaters have reduced risks of cardiovascular disease and cancer. This could be because fruit contains vitamins and fibre, which are good for health, as well as antioxidants that repair cells.

But how much fruit should you be eating? A study in the *BMJ* found that if you can stretch to seven portions of fruit and vegetables you're doing yourself some real favours. Risk of disease development over the course of the study reduced by 42 per cent for seven or more portions of fruit and veg. The government's current advice is five daily portions, but we still have problems reaching that target, let alone increasing it.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TIPS TO BOOST
YOUR HEALTH
14

CHOCOLATE

A little of what you like can do you good when it's chocolate

15

Substances called flavanols in cocoa work like blood pressure-lowering drugs called ACE inhibitors. Flavanols stimulate the body to produce nitrous oxide in the blood, which helps open up blood vessels. Researchers found regularly eating cocoa lowered blood pressure. But one per cent of people had stomach aches from over-indulging!

16

The beneficial effects of chocolate on blood pressure come from the high flavanol content, and the nitrous oxide, which dilates blood vessels. High blood pressure in the veins of the liver is thought to be linked with liver damage and chronic liver disease. Early research has shown that dark chocolate improves blood flow in the liver.

17

Cocoa contains polyphenols. Eating chocolate with high polyphenol levels (found in dark chocolate) could improve 'good' cholesterol levels, according to nutritionist Gaynor Bussell. "Cocoa consists mainly of stearic acid and oleic acid. Stearic acid is a saturated fat but doesn't raise blood cholesterol levels. Oleic acid doesn't raise it [either] and may even reduce it."

18

All the effects of chocolate on the circulatory system (lowering blood pressure, opening up blood vessels and reducing inflammation) can help keep our hearts healthy and ward off heart disease and stroke. A review of studies of more than 114,000 people found that those who ate the most chocolate were 37 per cent less likely to have coronary heart disease.

19

In a study reported in the *Journal Of Nutrition*, researchers examined the relationship between brain performance and chocolate consumption of 2,031 Kuwaiti men and women aged 70–74. Tests showed that those who had chocolate had significantly better cognitive performance than those who didn't.

20

People who eat chocolate regularly tend to be thinner, according to a study of more than 1,000 people. The researchers, who published their results in the *Archives Of Internal Medicine*, found people who ate chocolate a few times a week were, on average, slimmer than those who only ate it occasionally – even after the other foods in their diet were taken into account.

21

Researchers have found that some compounds in cocoa can actually help protect your skin from the sun. A study found that people who ate 20g of dark chocolate per day over 12 weeks could spend double the amount of time in front of a UV lamp before their skin reddened compared with those who had eaten normal chocolate.

22 GET THE GIFT OF GIVING

Research shows that spending money on others will make you happy even when you use your own hard-earned cash. The warm glow of giving emerges even in poor countries. This suggests that joy from giving might be a fundamental part of human nature. To test this idea, researchers gave toddlers cheese crackers. Their faces lit up when they received the fish-shaped treats, but they were even happier when they got the chance to give these treats away to a friendly puppet.

23 SLEEP MORE TO EAT LESS

More than 50 studies have looked into a possible link between sleep loss and weight gain, and reviews of the evidence have concluded that there is an association in both adults and children. Lack of sleep seems to disrupt the way we regulate hormones and metabolise glucose, and can cause increases in the hormone ghrelin, which stimulates appetite

24 GO TO WORK ON AN EGG

A few years ago we were being told by nutritionists not to eat more than a few eggs a week on the grounds that they contain cholesterol too much of which is bad for you. At the time, it was widely believed that elevated cholesterol in our blood is caused by cholesterol in our food. In fact, most of the excess cholesterol in our blood is produced by the liver and is a response to eating too much saturated fat. A meta-analysis of 17 studies published in the *BMJ* in 2013 concluded that "higher consumption of eggs is not associated with increased risk of coronary heart disease or stroke"

25 KEEP CALM AND CARRY ON WATCHING KITTENS

A study by researchers at Hiroshima University in Japan found that after students viewed images of kittens and puppies – as opposed to the adult animals – they were far more focused and performed better at a number-search game, as well as a game similar to Operation that required dexterity. This may be because the young animals triggered the participants' caregiving instinct, making them more attentive and vigilant.

26 PAY FOR THINGS UPFRONT

It's always tempting to whip out the plastic in a shop and take the item home straight away, then pay for it later in monthly instalments. But debt creates a serious drain on happiness. A study of over 2,000 people by researchers at the University of Sheffield found that individuals with unsecured debt were significantly less happy than those who were debt-free.

We prefer to offset payments because paying in smaller amounts feels instinctively better. But, neuroeconomists have found that there's an actual 'pain of paying' that we attempt to avoid. Scientists from Stanford University discovered that shoppers inside an MRI scanner experienced a pattern of brain activity akin to stubbing a toe when they were shown a retail item with a high price. So even though it may feel worse at the time, paying upfront to avoid debt paves a better pathway to happiness.

AVOCADOS CONTAIN CARBS, VITAMINS, MINERALS, FATS AND THE KEY 22 AMINO ACIDS NEEDED TO BUILD PROTEINS

27 DITCH THE DIET DRINKS

Even if the label on the bottle says sugar-free, research suggests you shouldn't be fooled into thinking it's any better for your waistline than a standard version. Health commentators argue there is little evidence that 'diet drinks' containing artificial sweeteners actually help people lose weight, and so should not be recommended as part of a healthy diet. In fact, many existing systematic reviews promoting the health benefits of diet drinks are sponsored by the soft drinks industry. According to a review by Imperial College London, these diet drinks stimulate sweet taste receptors, potentially encouraging us to eat food as compensation.

IN NUMBERS

1920s

THE DECADE IN WHICH THE FIRST WEIGHT LOSS DRUG AMPHETAMINE SALT WAS PATENTED

THE DAILY RECOMMENDED MAXIMUM AMOUNT OF SALT FOR ADULTS, WHICH IS ONE TEASPOON

6g

28 CHEW YOUR FOOD

There are tangible benefits to not scoffing your food besides good table manners. A study of nearly 60,000 Japanese people showed that those who ate slowly, or at 'normal speed', were less likely to become overweight than those who gobbled. It's thought that it takes 15–20 minutes for our body's feedback mechanisms to tell us we're full, so eating more slowly gives more of an opportunity for our brains to receive the signal.

30 PLAY CHESS

Chess grandmasters live longer than the general population, researchers at the University of Queensland have found. It's not yet clear why, but they think it's likely to be due to social and economic factors and a reduced risk of developing dementia

29

31 STICK TO YOUR ROUTINE

Many of us like to treat ourselves to a lie-in at the weekend. But going to sleep and waking up at different times during a week can disrupt your circadian rhythms – the brain's natural timing of sleep and wakefulness hormone release. Disrupted circadian rhythms are associated with sleepiness, fatigue, bad mood and health problems. A study from the Sleep and Health Research Program at the University of Arizona found that each hour of weekday to weekend lie-in 'lag' brings an 11 per cent increase in the likelihood of heart disease

GETTY IMAGES/X6 A. AMY

32

BE ACTIVE

Long-term tiredness is associated with too little activity. A University of Georgia review of research found 90 per cent of studies agree that people who regularly exercise report less fatigue than people who don't. Exercise increases levels of energy-promoting neurotransmitters, such as dopamine, norepinephrine and serotonin. It also resets the suprachiasmatic nucleus (SCN) – a group of cells that responds to light signals from the eye, and regulates sleep and wakefulness hormones. And exercise reduces fat stores, which seem to be associated with long-term fatigue.


50
TIPS TO BOOST
YOUR HEALTH

33

DRINK RESPONSIBLY

The Mayo Clinic in the US cautiously endorses the claim that there are potential health benefits to modest alcohol consumption. They include reducing your risk of developing and dying from heart disease, possibly reducing your risk of ischemic stroke, and possibly reducing your risk of diabetes.

There are many possible reasons for these benefits, one of which could be that red wine in particular has a positive effect on gut bacteria. Evidence for this comes from a number of sources, including a small study published in *The American Journal Of Clinical Nutrition* in 2012. Compared to when they were alcohol-free, when volunteers were drinking red wine, there were significant drops in blood pressure, in C-reactive proteins (CRP – a measure of inflammation), and in triglyceride levels (the amount of fat circulating in the blood).

34

RUN TO STAY SHARP

Scientists in France have found that research subjects who went for a 15-minute jog prior to taking cognitive tests were more mentally sharp than those who'd had 15 minutes' rest. They put the effect down to the increased feelings of vigour the runners enjoyed.

35

STAY IN SCHOOL

It seems that an education is good for more than just winning pub quizzes. A team in Vienna has found a link between education levels and life expectancy. Education gives people better self-control and forward-planning skills, according to the researchers.

36 FAVOUR THE COLD TAP

Most of the value of handwashing is the physical rubbing and rinsing action that dislodges bacteria from the skin's surface. A study at Rutgers University in the US found that hot water was no better than cold at removing *E coli*. In fact, water that is uncomfortably hot actually increases the bacterial load, because it damages the natural protective barrier of your skin.

37 BEWARE OF SIDE EFFECTS

Fatigue can be caused by prescribed and recreational drugs. It has been reported as a side effect of statins, allergy medications, hormone therapy and many cancer treatments. The high experienced with drugs such as cocaine, speed and ecstasy is often followed by a comedown of tiredness and depression. Scientists at Imperial College London showed that long-term smoking of marijuana lowers levels of dopamine – a brain chemical that plays a key role in motivation, pleasure and reward. If you're on prescription meds, look up possible side effects on the leaflet, and visit your doctor to discuss any concerns.

38 DON'T BELIEVE THE HYPE ABOUT WEIGHT LOSS PILLS

Dozens of 'metabolism-boosting' supplements, which often include ingredients such as caffeine, capsaicin, L-carnitine and green tea extract, claim to stimulate energy processing in the body, increasing the rate at which we burn calories. But there's little evidence that these products work, and most of their claims are not subject to scientific scrutiny because they are classed as food supplements rather than medicines. Some studies have indicated that people burn more calories when they take caffeine but, according to the Mayo Clinic, this doesn't appear to have any significant effect on weight loss. There is little data on most other 'fat-busting' pill ingredients, although there is some evidence from small studies that capsaicin, which is found naturally in chillies, can promote loss of abdominal fat and make people feel fuller.

DID YOU KNOW?

HALF AN HOUR OF SEX BURNS BETWEEN 150-250 CALORIES. WATCHING TV FOR THE SAME AMOUNT OF TIME BURNS ONLY 32 CALORIES.

39 SWAP SMOOTHIES FOR FRESH FRUIT

Don't be tempted to get your fruit fix by swigging back juices or smoothies. Many fruit juices contain large amounts of sugar. And juices that are 100 per cent fruit still contain almost as much sugar as a sweetened drink. Also, blending the fruit and veg to make smoothies changes the structure of fibre in the produce, which in some cases can reduce its beneficial effects. You're better off eating an orange rather than drinking it

40 STAY YOUNG AT HEART

People who feel younger than their age show fewer signs of brain aging in MRI scans, researchers at Seoul National University have found. This could be due to those who feel younger leading more physically and mentally

41 AVOID 'EMPTY' CALORIES

Empty calories are sugary foods that make you gain weight, but don't make you feel full. Fizzy drinks, fruit juices and sugary junk foods deliver large concentrations of sugar to the gut so quickly and easily that your intestines barely register it has hit them.

The key to a balanced diet is to eat proteins and complex carbs, such as brown rice, nuts and leafy vegetables as they take longer to break down. The result: the energy they contain is released slower and you get to feel fuelled up for longer and less prone to an energy drop.

"If you want to eat less then you have to have a strategy to make you feel more full, otherwise you're simply fighting hunger," says Dr Giles Yeo at Cambridge University's Institute of Metabolic Science. "As food goes down the gut different hormones keep being released, most of which give us a feeling of fullness. That's why high-protein diets can work, because protein is more complex than fat or carbs, and goes further down the gut before it's broken into its constituents."

42 LEARN A MUSICAL INSTRUMENT

Kids who take structured music lessons tend to do better than their non-musical peers in almost all areas of academic study, including visual arts, organisational skills and language-based reasoning, a study by Dutch scientists has found.

It's also likely to make your brain more efficient so it's able to perform a certain task with less effort than the brain of a non-musician – that's according to researchers at the Baycrest Centre for Geriatric Care in Canada

43 CONSIDER YOUR CROCKERY

Headline-grabbing studies have suggested that plate size, shape and colour, as well as cutlery size and weight, can affect how much you eat. Health experts continue to debate the merits of these findings. But there is little doubt that large portions contribute to weight gain, and an analysis in the *BMJ* recommended smaller tableware.

IN NUMBERS

20 minutes

THE TIME IT TAKES YOUR BRAIN TO SENSE YOUR STOMACH IS FULL WHEN EATING

19%

THE DROP IN SPERM CONCENTRATION IN MEN WHO SMOKE 20 OR MORE A DAY

44 LEARN ANOTHER LANGUAGE

A study at Montreal's Concordia University found that speaking a second language may help to protect you from age-related cognitive decline by boosting tissue density in brain areas associated with memory.

DID YOU KNOW?

AS WELL AS THE APPLE'S PURPORTED ABILITY TO KEEP THE DOCTOR AWAY, IT ALSO HELPS LOWER LEVELS OF BAD CHOLESTEROL

45 GET SOME SALT INTO YOUR DIET

46 SLEEP WELL TO FEND OFF DEPRESSION

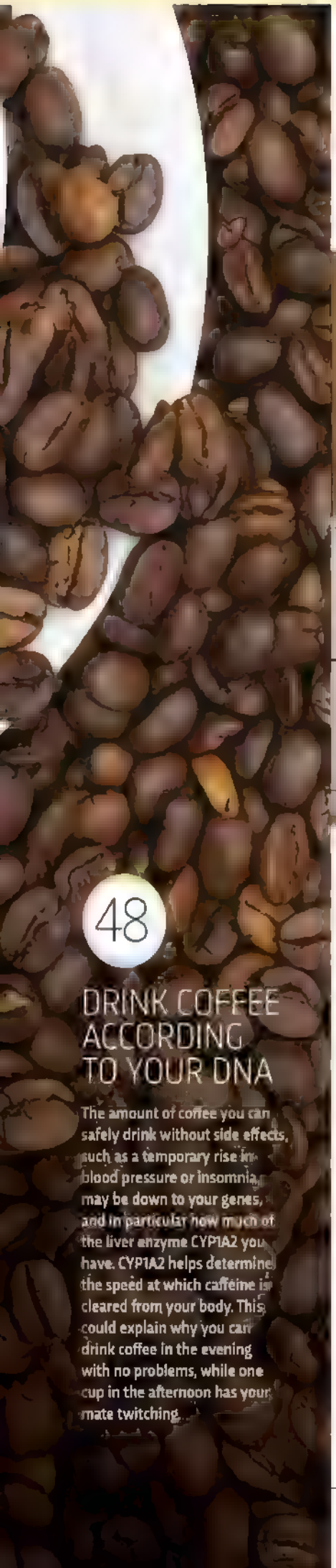
Lack of sleep and fatigue are strongly linked with depression and anxiety. Some researchers believe that widespread depression could be the reason why so many of us feel constantly tired. Studies carried out by the Texas A&M Institute for Neuroscience back this up. Researchers measuring brain oxygen levels of stressed people doing various tasks found they fatigued more quickly when completing complex mental activities. The brain's resources were being divided. So stress and mental frustration make us tire more easily. If you think you might suffer from depression, visit your doctor

47 CONTROL YOUR COFFEE CONSUMPTION

The Relationship Of Coffee Consumption With Mortality, a study of over 120,000 people over 20 years, concluded that "regular coffee consumption was not associated with an increased mortality rate in either men or women". In fact, its findings suggest, moderate coffee consumption appears to be mildly protective. Based on this and other studies, the most effective 'dose' seems to be two to five cups a day. More than that and any benefits drop off. More research is needed though as we simply don't know what it is in coffee that helps.

49 TAKE A NAP

Getting some daytime shut-eye gives your brain a chance to recharge. Researchers at the University of Pennsylvania found that people who napped for an hour at lunchtime performed better in memory and maths tests than those who stayed awake.

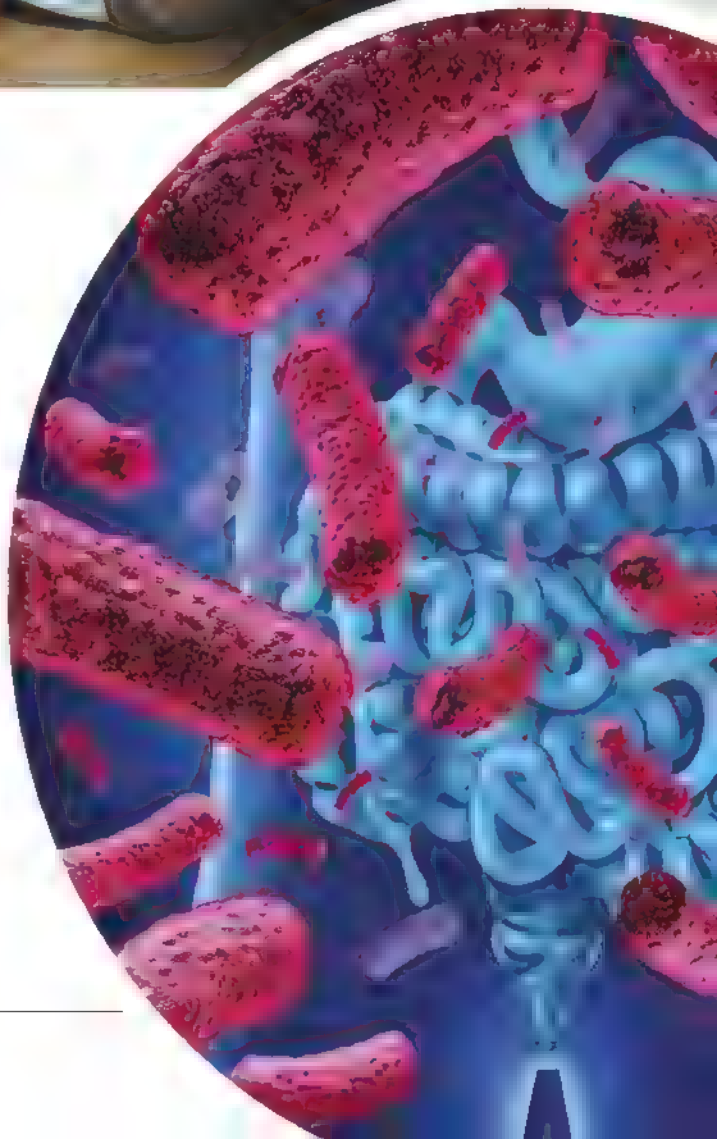


48 DRINK COFFEE ACCORDING TO YOUR DNA

The amount of coffee you can safely drink without side effects, such as a temporary rise in blood pressure or insomnia, may be down to your genes, and in particular how much of the liver enzyme CYP1A2 you have. CYP1A2 helps determine the speed at which caffeine is cleared from your body. This could explain why you can drink coffee in the evening with no problems, while one cup in the afternoon has your mate twitching.

50 NURTURE YOUR GUT BACTERIA

The past five years have seen interest in the idea that our gut bacteria play a crucial role in regulating weight and that killing them off with antibiotics is causing obesity. The most recent evidence is fascinating but inconclusive. One found that three courses of antibiotics before the age of two was associated with increased risk of early childhood obesity, while another found that exposure to antibiotics in the first six months of life was not associated with early childhood weight gain. Yet recent research is indicating a link between gut fauna and our body mass index. People with higher levels of *Christensenellaceae* bacteria – one in 10 of us – appear less likely to put on weight. Scientists from King's College London have found that levels of this bacteria are partly genetically determined.



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YOUR BODY

You know you should eat well, stay fit and get some good shut-eye. But what does science show are the best ways to do those things? In this section, discover the truth about fasting, superfoods and exercise trends, and how to de-stress and sleep well.

LIVE, FAST OR DIE YOUNG?

Intermittent fasting is becoming more popular. But is it any better than cutting your calorie intake over the long-term? And are there any risks?

words by HAYLEY BENNETT

Muslims do it. Christians do it. Even Buddhist monks do it. Eating less in the evening, or for a few days a month, is most definitely nothing new. What are new are the reasons for doing it. Until the last few decades, if you fasted, it was almost certainly for spiritual reasons; you were observing Ramadan, Lent or Vinyana – the Buddhist monk's daily fast following their midday meal. Today, though, a growing number of people fast for one reason and one reason alone: to lose weight.

Off the back of some best-selling diet books, fasting is more popular than it's ever been. All you have to do is keep your calories down for a couple of days each week, eat what you like the rest of the time and you'll still lose weight. That's the gist of the 5:2 diet anyway. But with popularity comes scrutiny, and scientists are now trying to work out whether there is any benefit to fasting diets that you can't get from a normal calorie restriction diet – in other words, just eating less all the time.

As it turns out, when intermittent fasting diets like the 5:2 hit the big time around 2012, there wasn't too much science to back them up. In fact, no one had done any quality long-term trials on humans at all. The only inklings we had that these fasting approaches might work – or were safe – were from studies on mice, where claims about weight loss were often tangled up with claims about resisting disease and living longer.

That hasn't stopped intermittent fasting diets becoming all the rage, and the pros and cons of various versions of these eating plans are regularly rolled out by health and beauty magazines, despite the lack of evidence. Now, though, scientists like Krista Varady, who is based at the University of Illinois, Chicago, are catching the research up to the rage.

There's only so much you can learn from animals with perfect adherence; if you put a mouse on a diet, there's really not much the mouse can do about it

EATING LIKE A MOUSE

Varady is interested in intermittent fasting as an alternative to everyday calorie restriction. "People quit those diets after about a month or two and they just get sick of the daily deprivation," she says. "With alternate-day fasting, or 5:2, you basically get a break from dieting every other day, or five days a week."

That's the basic premise behind intermittent fasting: that, for some people, eating less every day is just too hard, especially combined with working and socialising, which so often lead us into temptation.

Some of Varady's early studies were carried out on mice. But the way she sees it, there's only so much you can learn from animals with "perfect adherence"; if you put a mouse on a diet, there's really not much the mouse can do about it. People, however, are another matter. "I really became interested in whether people can actually do these diets?" she says. "It doesn't matter if the diets produce all these amazing results if people can't actually stick to them."

So, for the past decade, Varady has been trying to fill in the gaps in the evidence by studying fasting in humans. In 2017, this culminated in her publishing a year-long study on the effects of alternate-day fasting compared to regular, everyday calorie restriction in humans – the first long-term study of its kind.

In total, 100 people took part in the study and they were split into three groups. In the first group, 34 people tried an alternate-day fasting diet, where on fast days they ate just a quarter of their normal calories and on 'feast' days they consumed an additional quarter on top. Meanwhile, 31 people in a second group ate three quarters of their normal calories every day, meaning that, overall, the two groups reduced their calories by the same amount. For the first three months, both groups had the ingredients for all of their meals dished out to them at the research centre, after a weigh-in and some other health checks, but after that, they had to make their meals themselves, with help from a dietician. According to Varady, doing this kind of study is "a nightmare", because everyone taking part has different calorie goals to meet based on their normal eating habits and their diets have to be balanced for protein, carbohydrates and fats. There was also a third group consisting of 31 people, who ate their normal diet but came into the centre as often as the others to get weighed.

The question was: would the fasting group fare any better? No, as it turned out. Both dieting groups lost on average 7 per cent of their bodyweight over the first six months and didn't regain much of that weight over the second six months. Not only that, but both diets had about the same effect on other indicators of health status that the researchers checked. These included blood pressure, heart rate and cholesterol levels, as well as blood sugar

ABOVE Muslims that observe Ramadan will fast between sunrise and sunset

BELOW RIGHT Krista Varady (right) has been investigating the efficacy of intermittent-fasting diets

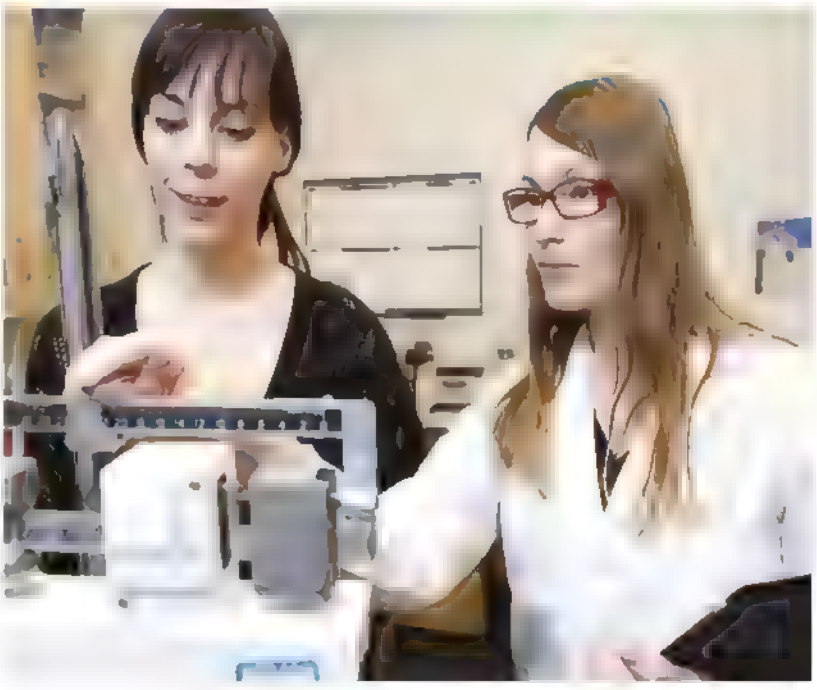
GETTY IMAGES, JC/ROBERTA OLIVEIRA DEVLIN

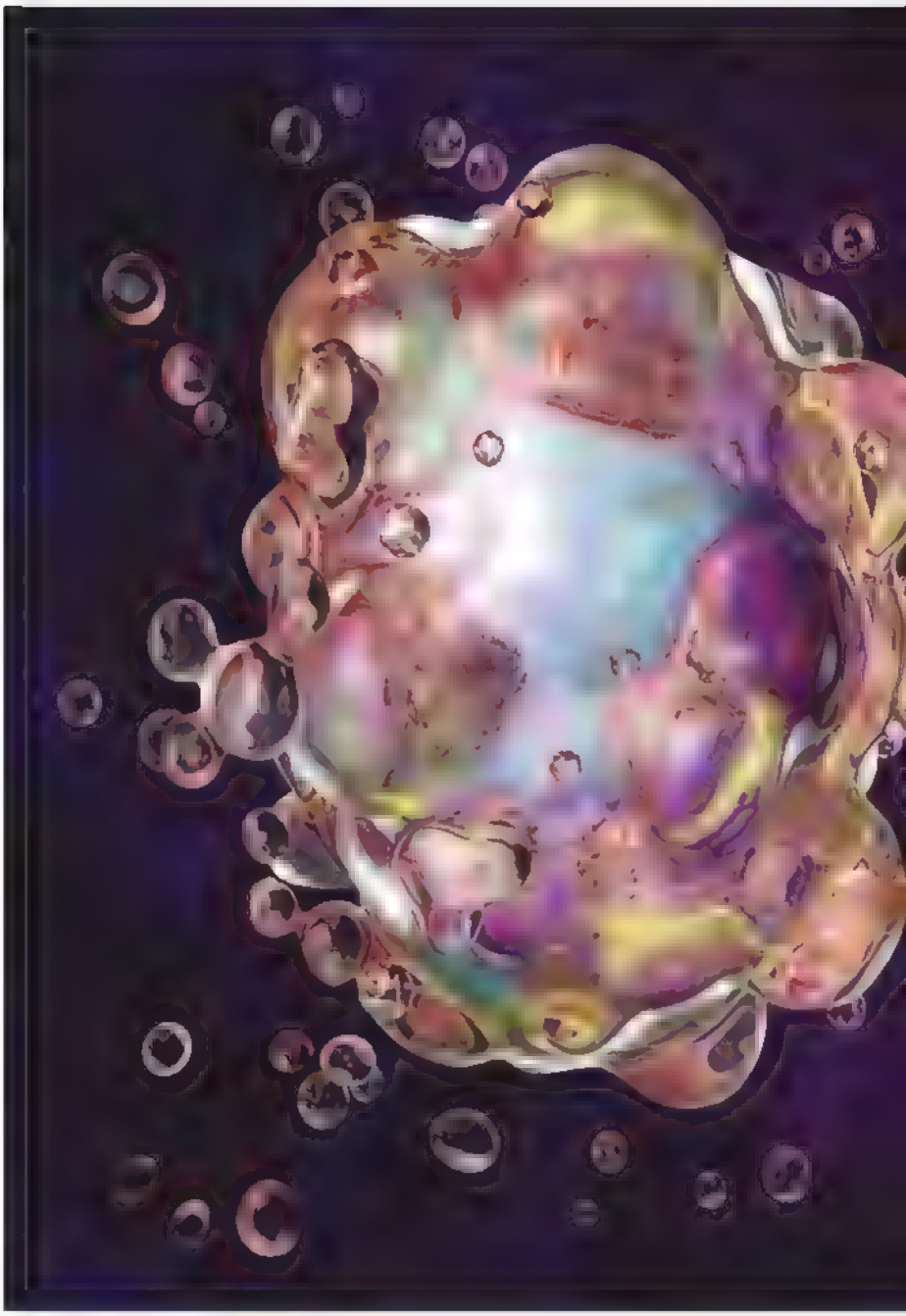
DO MUSLIMS GET HEALTHIER DURING RAMADAN?

During Ramadan, Muslims observe a fast between dawn and dusk. So does this fasting have some of the same benefits as intermittent fasting diets? Yes, but while studies do report weight loss, there are questions over whether Ramadan fasting is healthy for diabetic patients, for example. Doing a high-quality study on the effects of Ramadan is difficult because it would mean randomly assigning people to experimental and control groups, but people who do or do not normally fast during Ramadan may not want to switch groups. So instead, in a trial on 112 Muslims, Dr Romy Lauche (now a Visiting Fellow at the University of Technology Sydney) compared usual Ramadan fasting to 'modified' Ramadan fasting. The modified fasters were given info about the potential benefits of fasting for health and how nutritional changes might help them. This group did see some slight improvements over the usual fasting group, but Lauche says the soon-to-be-published study raises questions about "how to apply standard trial design to a compulsory religious practice".

and insulin levels, which are used to assess diabetes risk. In almost every aspect the diets were pretty evenly matched. What was perhaps most disappointing from Varady's point of view, though, was that the alternate-day fasters didn't find it any easier to stick to their diet than those who ate less every day. "I really thought that it would be easier to stick to the fasting diet," says Varady.

At this point, many in the press were already concluding that fasting diets didn't work. Then, in May 2018, a Brazilian group presented some results at the European Congress of Endocrinology that caused a stir, because they suggested that fasting could increase diabetes risk. Working with mice, Ana Bonassa and her colleagues had shown that alternate-day fasting for 12 weeks damaged the pancreas and increased production of insulin, the





hormone that controls blood sugar levels. Although unpublished, theirs was the first study to show such a link.

Since then, the team has found that the damage seemed to be caused by reactive molecules called free radicals triggering a process of cell death – apoptosis – at a faster rate than usual. As Bonassa explains, "Apoptosis is an important process in the body to maintain normal functioning... The problem arises when the rate of apoptosis is greater than the rate of cell replication, and tissue damage may occur in the long run."

LIMITING THE DAMAGE

However, Bonassa's experiments tested what might be considered an extreme version of the diet, where mice didn't eat at all on fasting days. Mice have especially fast metabolisms and eat frequently through the day, so it is difficult to extend the results to humans. But these studies are just a starting point. Bonassa says figuring out feed strategies that result in less damage is a future focus. She's also interested in how the timing of shorter, daily fasts impacts our health. "For example, studies performed in humans have shown that when fasting is practised later in the day, there are positive results, such as decreased risk factors for diabetes," she says. Interestingly, this is the same approach that Buddhist monks take to fasting.

Meanwhile, many are still flocking to try fasting diets for themselves. The current state

LEFT Research suggests fasting diets may be linked to an increase in the rate of apoptosis – programmed cell death

Buddhist monks often observe a daily fast after their lunch

By looking at how the best weight-losers lost more weight, they found that people who ate more protein did better because they tended to feel fuller

of the science tells us it's unlikely to do you much harm if – rather than observing a true fast – you simply eat less on fast days. But if, on average, it only works as well as an ordinary eat-less-every-day diet, why bother? Well, because that's just an average and some people inevitably do better on a given diet than others. In a follow-up to their year-long study, Varady's team tried to work out why. By looking closely at how the best weight-losers lost more weight, they found that people who ate more protein did better because they tended to feel fuller. They're now testing fasting plans that incorporate elements of so-called low-carb diets and seeing fascinating results. "I have to say we're seeing almost twice the weight loss we've seen in any other study up to this point," says Varady.

The flaw in the science, according to Varady, is that researchers have to randomly assign people to different diet programmes. "It doesn't make any sense," she says. "There's no one perfect diet because diets work differently for everyone." This is, obviously, not the way it works in real life, where people pick diets to suit their personalities and lifestyles. If fasting during Ramadan didn't suit you, then you'd choose not to do it, and if you didn't want to miss your evening meal every day, then you probably wouldn't become a Buddhist monk. **SF**

BY HAYLEY BENNETT

Hayley is a science writer based in Bristol

WORLD SERVICE

Listen to the CrowdScience programme *Is Fasting Healthy?* bbc.in/2BskdHD

THE TRUTH ABOUT SUPERFOODS

Kale and chia, goji berries and blueberries, salmon and spinach... Are these superfoods really the magic bullets they claim to be?

words by JAMIE MILLAR

Billed as the superheroes of the culinary world, so-called superfoods are almost as widespread as comic-book movies. Every day seems to bring news of another exotic ingredient capable of bestowing extraordinary health benefits to anyone that eats it. It's claimed that these superfoods can transform our diets and improve our health. The problem is no one knows exactly what a superfood is.

"There is neither a regulatory nor a scientific definition of a 'superfood'," says Dr Jeffrey Blumberg, from the Friedman School of Nutrition Science and Policy at Tufts University, Boston. "It is a marketing term which marketers do not wish to define either." But by reading the books and blogs that use the term, some common characteristics can be discerned.

Superfoods typically have high levels of certain nutrients (vitamin C, beta carotene or iron, for example) and they're often exotic in origin – the goji berry hails from the Himalayas. "This seems to suggest that they have some special health-promoting properties," says Blumberg. "Although the countries from which they come are not characterised by especially healthful or long-lived people."

Superfoods are often repackaged staples of bygone and remote societies, which gives them a quasi-mythical air. The goji berry, for example, allegedly helped Chinese herbalist Li Ching Yuen live to the ripe old (unverified) age of 256. Coincidentally, he also sold goji berries. Which leads us to what might be the defining characteristic of superfoods – they're expensive.

A HEALTHY PINCH OF SALT

The appetite for superfoods is growing – according to the International Food Information Council, nearly nine in 10 Americans are interested in foods that may have health benefits beyond basic nutrition. But along with these foods come a lot of unsubstantiated claims. The thing to bear in mind when you're considering adding them to your shopping list is that there's scarcely a grain of proof for the efficacy of the goji berry or any other superfood.

A Chinese study of 79 patients with advanced cancers found that their conditions regressed when treated with goji polysaccharides, alongside immunotherapy. But information about the design of the study and the compounds used is, like evidence for most claims related to goji berries, lacking. Another study, on goji juice's effects on brain activity, was only performed on 34 people, and inconclusive. Most of the studies related to goji and immunity, heart disease and life expectancy have been either small or used concentrated extracts that equate to an amount of the real-life fruit that would be practically impossible to consume.

It's a similar case with antioxidants. The presence of high levels of antioxidants in a food, super or otherwise, won't necessarily ▶

GETTY IMAGES

INSTANT DIGEST

EVERYDAY HEROES

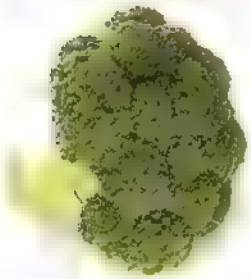
They're not new or exotic, and they don't always grab the headlines. But if these widely available 'superfoods' aren't already in your kitchen, they should be

GARLIC

Better known for warding off vampires and first dates, there is evidence the bulb can lower blood pressure and cholesterol, plus even prevent colds and certain cancers.

EXTRA-VIRGIN OLIVE OIL

A Mediterranean mainstay, the healthy fats in this cure-oil cut cardiovascular disease and inflammation. But don't fry with it, as high heat damages its nutrients.



BROCCOLI

Containing high levels of vitamin C and folate (natural folic acid), this fibrous cruciferous vegetable can lower cholesterol and triglycerides, which cause cardiovascular disease.

APPLE

Crunching this doctor-deterring fruit, which is high in antioxidants and fibre, has been associated with reduced risk of cardiovascular disease, diabetes, asthma and some cancers.

ONION

A member of the allium family, it contains a potent anti-inflammatory antioxidant called quercetin, which reduces blood pressure and lowers the risk of cancer.

WALNUT

This has the highest antioxidant activity of any nut and is the only one with a significant amount of omega-3. There's also evidence to suggest it could stave off cardiovascular disease.

TOMATO

Technically a fruit, it is low in starch and sugar, but high in fibre, vitamin C, beta-carotene and a potent antioxidant called lycopene. Cooking in olive oil increases its absorption.

BEETROOT

Rich in iron and folate, beetroot can make you hard to beat – its nitrates lower blood pressure while some studies show improved exercise performance after consuming it.

SPINACH

Popeye's preferred superfood packs high levels of bone-strengthening calcium and vitamin K, as well as vitamin A. And it contains almost as much iron as beef.

SALMON

Think pink. Oily fish reduces cardiovascular disease risk, lowering blood pressure, and lubricating arterial fat build-up. Salmon is high in omega-3, vitamin D, some B vitamins and selenium.

"What people should be wary of are studies conducted in house by food companies, which are close to worthless"

result in a proportional antioxidant effect on your body. For example, anthocyanins, found in blueberries, have been shown to inhibit growth of cancerous human colon cells in vitro. But there's no evidence that the flavonoids, the class of antioxidants that anthocyanins belong to, are even absorbed in the human body – studies show that less than five per cent survives consumption and is promptly excreted. "When you consume an antioxidant, the main antioxidant effect often comes from your body's reaction to eating a foreign substance, rather than from the substance itself," says Kamal Patel, a nutrition researcher and director of examine.com, an independent study analysis website. "Plus, our body's own antioxidant systems – involving compounds like glutathione – are more powerful than what we can get from food."

TRICKY TO STUDY

The proof of the superfood pudding is in the eating – by humans, not lab rats or mice. But unfortunately, most scientific research isn't conducted this way. Lifestyle factors are difficult if not impossible to separate, and pilot studies and animal trials will often use unrealistically large doses. Meanwhile, eating different foods alongside the superfood, which is what most of us do, can dramatically alter their effects, for better or worse.

Another issue affecting superfood research is that it's often paid for by interested parties. "We're funded by food and supplement companies in many of the studies we conduct," admits Prof David Nieman, director of the Human Performance Labs at Appalachian State University in North Carolina. "But the system demands a contractual agreement that gives the primary investigator 'academic freedom', or the right to publish the data, positive or negative. Many of the companies I work with are so convinced that their product has special effects that they sign these agreements. What people should be wary of are studies conducted in-house by companies, which are close to worthless."

But while industry-funded doesn't mean false, the anointed superfood might not be much better than a cheaper, less exotic equivalent that doesn't have the same commercial imperative.

If such things as superfoods exist, then they're hiding behind their secret identities as the mild-mannered Clark Kents of the supermarket produce section. "Garlic has a tonne of evidence," says Patel. "And potatoes are cheap, nutritious and filling, yet they don't get much attention."

So, rather than spend a fortune on superfoods, think of your diet as like the Avengers – a diverse assortment of colourful characters with different powers that work together. And the largest part of it should be green. **SF**

Popular among celebrities from Madonna to Miranda Kerr, goji berries have high levels of certain nutrients

BBC 4

Find out how diet affects the brain in *How To Have A Better Brain Diet*
bbc.in/2FUzPJl

by JAMIE MILLAR
Jamie is a freelance writer and contributing editor to Men's Health


WHAT'S
IN THE
BRITISH
GUT?

SCIENTISTS ARE SEARCHING FOR THE BACTERIAL PROFILE OF BRITISH PEOPLE'S GUTS, AS THE SUBTLE DIFFERENCES BETWEEN THE CONTENTS OF OURS AND THOSE OF PEOPLE ON OTHER CONTINENTS COULD TELL US MORE ABOUT OUR HEALTH THAN OUR GENES

words by AMY FLEMING

Species-wise, you probably identify as human. But based on the number of cells in and on your body, you are actually more microbe, because trillions of them call you home. Your human genes are outnumbered by microbial genes and, as the scientists exploring our microbial ecosystems (known as our microbiomes) are discovering, the armies of tiny freeloaders our bodies host are quietly controlling us. Together, they can govern mood, appetite and immune responses, as well as help to digest and metabolise foods.

In some ways, our microbes are more influential in shaping who we are and how we feel than our genes, says Prof Tim Spector, who runs a microbiome research unit at King's College London called the British Gut Project. "I can tell more about someone's health by getting a detailed screen of their microbes than by screening their genes," he says, pointing out that we're 99.7 per cent genetically similar, whereas "we only share about 20 or 30 per cent of our microbes."

THERE ARE MICROORGANISMS LIVING ALL OVER OUR BODIES... BUT THE CONTROL CENTRE LIES IN THE GUT, WHICH SOME RESEARCHERS CREEPILY REFER TO AS THE SECOND BRAIN

A CENSUS OF YOUR GUT

Spector started the British Gut Project in 2014 to map as many people's microbiomes as possible, so as to reveal associations between our biomes and health. He had started studying stool samples from the vast King's College twins research registry he's led for 25 years, and was inspired by microbiologists in the US who had launched a crowd-funded study called American Gut. The shared aim of the British and American Gut projects is to build vast banks of gut data by inviting the public to participate. For a small fee, which is used to fund the work, participants get to discover which rare species they're harbouring, how their microbiome compares with others in their country and, says Spector, they're working on adding a "diversity score", because the more different types of microbes we host, the healthier we tend to be.

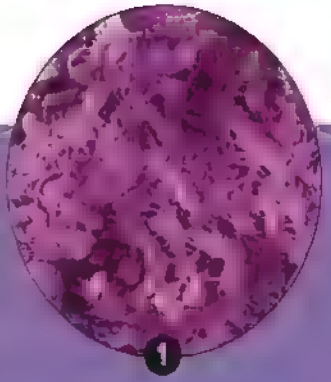
The samples collected by the British Gut Project are sent to the American Gut laboratory in San Diego for analysis. British Gut is, essentially, the European wing of American Gut, which

ABOVE Prof Tim Spector believes a diet consisting of a diverse range of plants and whole foods promotes a more diverse microbiome

is working with an expanding network of researchers around the world, seeking to do the same. All the resulting data are open source and will form part of the ambitious Earth Microbiome Project, a collaborative international push to characterise microbial life on Earth.

There are microorganisms such as bacteria and yeasts living all over our bodies, from toes to nose, which is why the British Gut Project will also accept swabs taken from skin, mouths and vaginas. But the control centre lies in the gut, which some researchers somewhat creepily refer to as the second brain. (Finally there's a scientific basis for the idea of 'gut instinct'.) By analysing the living contents of our guts via stool samples, researchers can identify geographical differences – such as that American microbiomes tend to be less diverse than their British counterparts – and links between certain microbes and common diseases.

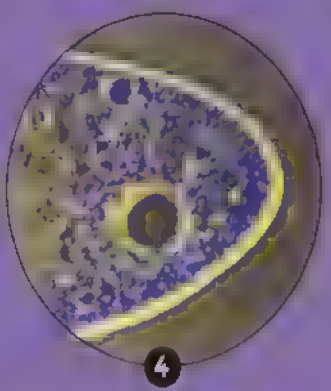
WHAT'S IN YOUR MICROBIOME?



1 **Bacteria**

2 **Fungi**

3 **Yeasts**



4 **Protozoa**

5 **Archaea**

THERE ARE WAYS THAT YOUR BODY CAN WARN YOU THAT YOUR GUT FLORA ISN'T FLOURISHING. HAVING IRRITABLE BOWEL SYNDROME CAN BE A SIGN, ALONG WITH BEING CONSTIPATED

Currently, says Spector, microbiome knowledge is 10 years behind human genetic research. We've only scratched the surface in identifying all the microbes, learning what they do and how they work together. But we have identified a group of microbes that seem to be beneficial in most people. People with diabetes, rheumatoid arthritis, food allergies, irritable bowel syndrome (IBS), colitis and high blood pressure, says Spector, "tend to lack these beneficial microbes that in other people are protective".

There are strong links, also, between mental health and gut health. Prof Felice Jacka, who runs the Food and Mood Lab at Deakin University in Australia, first established the field of nutritional psychiatry a decade ago and her research is increasingly turning to microbes. "All the factors that underpin depression from a biological point of view are under the regulation of the gut microbiome: inflammation, brain plasticity, immune activation in the brain, gene expression. It also affects the level of neurotransmitters in the brain and has a very important role in modulating the stress response system," she says.

Even the effects of foods and drugs on our systems (from antidepressants to cancer chemotherapy) are related to the microbes we have. "If you're on cancer chemotherapy," says Spector, "and you have the right type of microbes, you'll be three times as likely to survive. So everybody going onto cancer chemotherapy should be getting their microbiome tested." If it's found that you don't have the necessary microbes, taking probiotic supplements containing helpful bacteria and making dietary changes, he says, may well improve your chance of living. "American cancer centres are now routinely screening their patients and offering advice," notes Spector, whereas the gut-chemo axis hasn't reached British doctors' agendas yet.

This is one among many examples where taking probiotic supplements has been shown to be effective. "It's looking like they do work for a wide variety of conditions," says Spector. "If you've got a child with diarrhoea, giving them probiotics will significantly speed up recovery time." Jane A Foster, associate professor in psychiatry and behavioural neurosciences at McMaster University in Canada, describes the probiotics industry as a "flourishing landscape" and foresees a time when probiotics will be in our orange juice and chocolate bars. But she warns probiotics aren't always the solution. "The microbiome is partly driven by our own genetics and partly by environmental factors such as stress, diet, age and gender. All these

SCIENCE PHOTO LIBRARY

There are around 1,000 species of bacteria living on your skin – seen here are a few of them (and a red blood cell) found in a swab from someone's fingertip

things affect the composition, and probably also the function of the bacteria that are there."

In other words, it's not simply a cause and effect relationship between the amount of good and bad bacteria in your gut. "The only way bad bacteria's effects are understood is when we have enough of them to constitute an infection and we have terrible gastrointestinal symptoms such as vomiting and diarrhoea (due to *E. coli* or *C. difficile*, for example)," explains Spector. "In terms of our gut flora, it's not yet possible to prove a causal role for any bacteria, as it's not understood how they all interact in the body. Many of them can't survive outside the body so we can't study them in action. The way scientists find out about what bacteria we have is by finding their DNA."

HAPPINESS IS A HEALTHY GUT

There are ways that your body can warn you that your gut flora isn't flourishing. Having IBS can be a sign, along with, says Spector, "being constipated, having a limited diet, feeling bloated; on average, if you're overweight, unwell and have lots of allergies, you're going to have poor gut health". For many, he says, this is

MAIL-ORDER GUT TESTING

For £149, **ATLAS BIOMED** will provide a breakdown of your gut flora's diversity, its ability to digest fibre, your susceptibility to diseases such as ulcerative colitis, Crohn's disease, obesity and type 2 diabetes, and the nationality your diet most resembles. You will also receive personalised dietary advice on how to strengthen your microbiome through diet. *atlasbiomed.com*

UBIOME offers tests on bacteria from your gut, mouth, nose, genitals and skin – the basic uBiome Explorer kit costs $89 (£68) plus postage to the US. The results will compare your gut health with vegetarians and meat eaters, assess the diversity of your microbes, and how well your flora will metabolise carbs, caffeine and other substances. *ubiome.com*

As well as offering a gut-health test for $149 (£114), **THRYVE** also sells packages that deliver a health report and food recommendations along with probiotic supplements (or a monthly subscription if desired) and a step-by-step diet plan. *thryveinside.com*

With **CARBIOTIX**, the emphasis is on boosting the friendly bacteria in your gut by feeding it the soluble fibre, through diet and Carbiotix's prebiotic supplements (essentially fertilisers for your gut flora). To avoid filling yourself with more fibre than your bacteria can eat, Carbiotix tests your gut flora monthly so you can monitor the situation and build your flora and fibre intake accordingly. It's among the cheapest tests going – either a one-time test of £21 or a monthly test at £21 a month. *carbiotix.com*

9 WAYS TO BOOST YOUR MICROBIOME

The microbes in your gut can help you to get slimmer, be happier and live longer. Here's how you can give them a helping hand...

1 UP YOUR FIBRE INTAKE

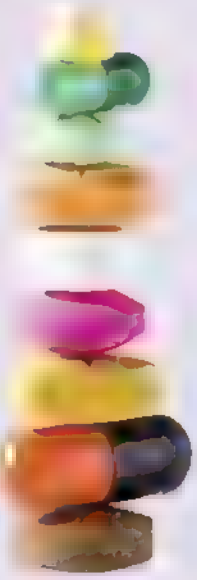
Aim for more than 40g per day, which is about double the current averages. Fibre intake has been shown to reduce heart disease and some cancers, as well as reduce weight gain.

2 EAT A VARIETY OF FRUIT AND VEGETABLES

Each fruit and veg support different microbial species. Pick high-fibre veg, such as artichokes, leeks, onions and garlic, which all contain high levels of inulin (a prebiotic fibre). Lettuce has little fibre or nutrient value.

3 AVOID UNNECESSARY SUPPLEMENTS

Only a tiny proportion of supplements have been shown to be beneficial. Instead, focus on eating a diverse range of real food to get all your nutrients. Only consider supplements if there is a nutritional shortfall that can't be covered by your diet.



4 STEER CLEAR OF ANTIBIOTICS

Antibiotics destroy good and bad microbes, which can take weeks to recover, so don't take them unless you need them. Their use is also associated with obesity and allergies in animals Even paracetamol and antacids can interfere with microbes.

5 AVOID ARTIFICIAL SWEETNERS

Aspartame, sucralose and saccharine disrupt the metabolism of microbes and reduce gut diversity – in animal studies this has led to obesity and diabetes. Ditch the processed foods too, as these also upset microbe metabolism

6 CONSUME ANTIOXIDANTS

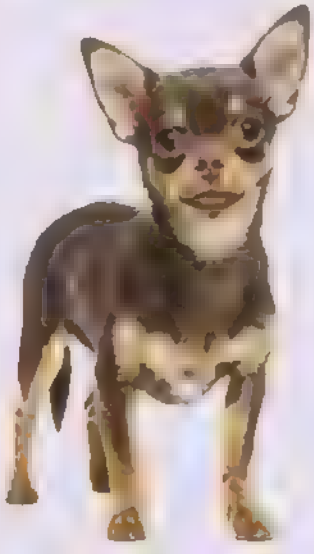
Polyphenols in nuts, seeds and tea are antioxidants that act as fuel for microbes.

7 GO WILD

People living in rural areas have better microbes than city-dwellers. Gardening and other outdoor activities are good for your microbiome. Excessive washing and use of antibacterial sprays may not be.

8 STROKE ANIMALS

Studies have shown that people living with dogs have more microbial diversity.



9 CONSUME FERMENTED FOOD

Good choices are unsweetened yoghurt; the sour milk drink kefir; raw milk cheeses; sauerkraut; the Korean dish kimchi; and soybean-based products such as soy sauce.

the norm and it's only when you change it and begin to feel better that you realise how bad it was. Your immune system improves and you have fewer colds and infections.

To improve gut health, Spector advises doubling your fibre intake – eating whole foods, such as grains and beans, and plenty of fruits and vegetables. Fermented foods such as yoghurt, sauerkraut and the national pickle of Korea, kimchi, are packed with friendly bacteria. And according to Spector, the number one result so far from the British Gut Project (which has had nearly 7,000 participants) is that the people with the healthiest guts consume the most diverse number of plants. "Whether you're vegetarian, a carnivore, on the paleo diet or whatever, if you get a range of plants on your plate – be they seeds, nuts, spices, herbs, fruits, vegetables, mushrooms, grains – it's the variety that's key."

TO IMPROVE GUT HEALTH, PROF SPECTOR ADVISES DOUBLING YOUR FIBRE INTAKE – EATING WHOLE FOODS, SUCH AS GRAINS AND BEANS, AND PLENTY OF FRUIT AND VEGETABLES

PERSONALISED NUTRITIONAL ADVICE

Peak gut health corresponds with eating 30 different plant foods each week, and American Gut reports that those in this group were also found to have the least antibiotic-resistant bacteria genes in their guts. The researchers wondered whether this could be because the participants were eating less meat and processed foods tainted with antibiotics. (Unsurprisingly, they found that taking a course of antibiotics within the past month resulted in a less diverse microbiome than in those who hadn't taken these medicines in the previous year.)

Spector has since launched a second phase of gut research, called the Predict Study, which looks at personal responses to different foods and how this corresponds with the gut flora. The goal is to offer personalised nutritional advice by looking at your gut microbes. Participants in the study, including Spector himself, test their blood glucose levels after consuming everything from bananas to prosecco. The responses, he says, vary widely, even in identical twins, "not because of their genes but because of their microbes." Frequent glucose spikes are related to an increase in weight and diabetes, and Spector has discovered that these occur in him when he eats bread, whether it's white or wholemeal. "If I eat pasta or rice," he says, "I don't get a spike, whereas other people might have the opposite. It's the microbes determining that. So if you can find foods that support your glucose levels, then you're more likely to lose weight long term."

This is partly why he believes microbe testing will end up becoming routine. Web-based microbiome testing services are already around £100 he points out, "and as more people use them it's going to come down. If the NHS did it, the price would be below £20 – the same price as a blood test and instantly more useful."

Eventually, he says, "I could test your gut microbe and say, based on our database of 10,000 people, whether you should be a rice person rather than a potato person." One British and American Gut finding already defends alcohol in the ongoing scientific debate over whether any booze can ever be healthy. Happily for moderate drinkers, those who consume alcohol once or more per week have more diverse microbiomes than abstainers. And as the numbers get bigger, more detailed and subtle geographical differences will become clear, along with gut signifiers of disease and the effects of specific diets. **SF**

by AMY FLEMING
Amy is a freelance science writer and editor

THE NEW WAYS TO GET FIT

There isn't yet a pill to replace exercise. And a drug being developed to break down fat for energy is still several trials away. Until they arrive, the following fitness trends driven by scientific advances could help you get in shape...

words by JAMIE MILLAR

High-intensity interval training has been shown to have many benefits

HIGH-INTENSITY INTERVAL TRAINING (HIIT)

Few forms of exercise have been as highly researched or publicised in recent years as high-intensity interval training (HIIT). In 2018, HIIT headed up the yearly survey of worldwide fitness trends by the American College of Sports Medicine.

High-intensity intervals are exercises that you typically perform at 80 to 95 per cent of your maximum heart rate, for anywhere from five seconds to eight minutes. The work intervals are alternated with periods of rest or active recovery performed at 40 to 50 per cent of your maximum heart rate, lasting for the same duration.

HIIT has many benefits: it's efficient (a workout can take as little as 20 minutes); it can be done on gym equipment or via exercises such as press-ups; and it's adaptable to varying fitness levels, which partly explains its popularity among everybody from elite athletes to cardiac rehab patients.

The good news is that HIIT has been shown to improve fitness, cardiovascular health, and insulin sensitivity – which is of particular significance to diabetics. HIIT also reduces fat (both abdominal and the deep, visceral kind that engulfs your inner organs) while maintaining muscle mass or, in less active people, increasing it.

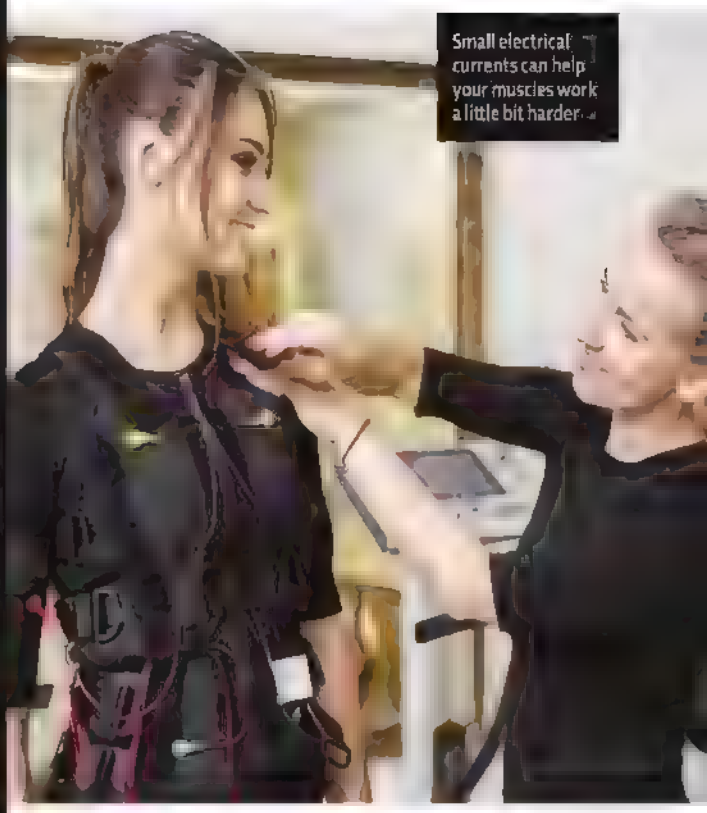
But it's not all good news. A study in the *Federation Of American Societies For Experimental Biology* journal showed that, in newcomers, interval training can halve the function of mitochondria (the power packs of your cells). And just one overzealous spin class can be enough to trigger rhabdomyolysis, where muscle fibres break down and leak into the bloodstream, which can lead to kidney failure. But, although HIIT may also raise coronary risk for sedentary people, it's considered safe for most if correctly prescribed.

You can quickly improve your health simply by getting more sleep

SLEEP

What if there was a performance-enhancing drug that could make you faster, stronger and leaner? That raised your testosterone, growth hormone, immunity and pain tolerance? That was widely available and perfectly legal? Well, there is: it's called sleep. When varsity basketball players at Stanford upped their nightly dose of vitamin ZZZ from eight hours to 10, and maintained it for five to seven weeks, not only did their sprint and reaction times pick up, but also their free-throw accuracy and successful three-point attempts – both by nine per cent. Additionally, their mood lifted and fatigue decreased. Conversely, a study in the *Journal Of Strength And Conditioning Research* found that four hours of sleep deprivation left judo players feeling drained the next day. Meanwhile, Uppsala University in Sweden has demonstrated that just one night of tossing and turning is enough for you to shed muscle and stockpile fat; long-term shut-eye deficiency is linked to an elevated risk of heart disease, high blood pressure, diabetes and dying earlier. And Dave Brailsford, the former performance director of British Cycling who ushered in its golden medal era, famously insisted on athletes travelling with their own pillows, duvets and mattresses.

As more research emerges on the boons of extended stays in the land of nod, more and higher quality sleep is becoming a goal. Wearable tech firm FitBit has introduced a 'sleep score', Apple has bought mattress sensor Beddit, and American health club Equinox has developed a 'sleep coaching' programme proven by researchers at UCLA to help members workout longer and at higher intensities – they reduced their body fat by 17.2 per cent, versus 7.1 per cent for people who just received regular personal training. You snooze, you gain.



Small electrical currents can help your muscles work a little bit harder

ELECTRICAL MUSCLE STIMULATION (EMS)

Banish thoughts of those devices advertised on home shopping channels that claim that you can acquire a six-pack by lying on the sofa while a couple of pads jiggle your belly. Well, not all thoughts. EMS involves being wired up to a full-body suit while you exercise. As the name suggests, it forces your muscles to contract more powerfully by zapping them with low-level electrical currents, vibrating them up to 80 times per second; because of that, you can supposedly reap the equivalent benefits of training for an hour in as little as 20 minutes.

EMS has hitherto been used to prevent or recover from muscle wastage. A study in the *Archives Of Physical Medicine And Rehabilitation* showed that it was effective for elderly patients who developed hip osteoarthritis after arthroscopic surgery. And now the tech is also being used by the likes of *Spider-Man* actor Tom Holland and Olympic sprinting legend Usain Bolt – although critics question whether it can amp up athletic performance. Nevertheless, German EMS purveyor Miha Bodytec opened its first UK studio in Canary Wharf in 2017, and was named as one of Europe's 1,000 Fastest-Growing Companies by the *Financial Times*.

Travelling without moving: get the benefits of cycling without going outdoors

VIRTUAL REALITY

VR fitness might sound like the stuff of science fiction, but it's very much today's reality. An estimated 12,000 health clubs around the world are already augmenting their exercise classes with cinema-quality video and audio in order to create a more immersive – and inspiring – experience. For example, 'immersive' cycling class The Trip by workout company Les Mills (which pioneered Bodypump in the 1980s) takes you around digital velodromes, up glaciers, beneath the waves and even back in time to ancient Greece, all while on a stationary bike.

In a study led by researchers from Penn State University, subjects who took The Trip reported a lower level of perceived exertion – they felt like it was less difficult – than subjects who took an audio-only class, even though the intensity was the same for both. This was presumably because the high-tech visuals distracted from the physical discomfort and slow-moving clock. The VR cyclists also declared themselves more satisfied with the overall experience, which may increase people's likelihood of sticking with regular activity. As might the fact that VR enables you to take a class at your own convenience, without an in-the-flesh instructor, which makes it appealing to cost-conscious gym operators too.

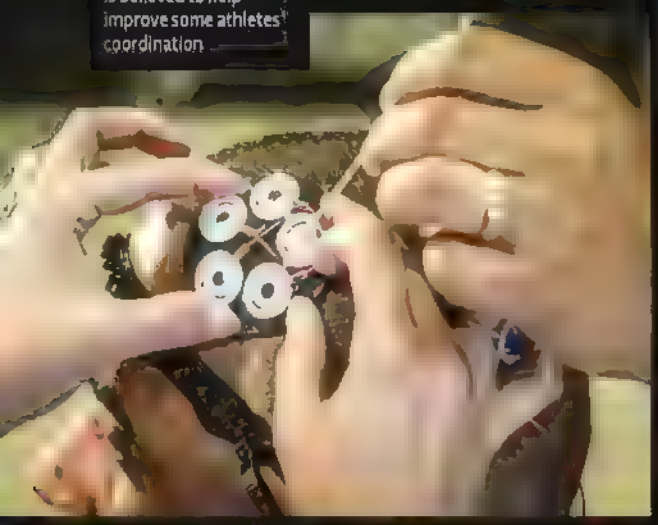
Interestingly though, early data indicates that, rather than making trainers and timetables obsolete, VR actually increases the attendance at live classes by an average of 12 per cent. (The theory is that it acts as a less intimidating gateway to group training for the less confident.)

ROWING

Over the past year or two, rowing has followed in boxing's wake in being dubbed 'the new spinning'. That's thanks to the fleet of dedicated boutique studios that have launched recently, from City Row and Row House in New York (where workout trends tend to start) to Metabolic London and The Engine Room here in the UK.

Rowing is a full-body workout that press-gangs 85 per cent of your muscles, from nine major groups, into service. Plus it works both your aerobic and anaerobic energy systems (your body's ability to produce energy with and without oxygen, respectively). And although you might be able to burn more calories in the same time on other pieces of exercise equipment, that's not a complete reflection of their efficacy. Penn State University has determined that the rowing machine is more taxing than a treadmill or stationary bike, while a study in *The Strength And Conditioning Journal* found that performing high-intensity interval training on one is as metabolically demanding as mixed martial arts training. The difference being that with rowing, you'll only feel like you've been punched in the gut.

Rowing is a full-body exercise that works nine of your major muscle groups



Transcranial stimulation is believed to help improve some athletes' coordination

TRANSCRANIAL DIRECT-CURRENT STIMULATION

Strapping electrodes to your head to stimulate it directly with electricity may sound scary, but non-invasive transcranial direct-current stimulation (tCDS) is safe – it uses a minute charge and feels tingly but not painful.

It boasts many potential applications (see page 86), but one of the most buzzworthy is in the sporting arena. The brainchild of US researchers who developed neurostimulation devices for epilepsy patients, Halo Sport headsets resemble a pair of over-ear headphones, albeit with rows of rubber electrodes along the band. According to the makers, firing electrical pulses into your motor cortex, which is responsible for coordination, for 20 minutes can trigger a temporary state of hyperplasticity, in which your brain is more receptive to learning or reinforcing movement patterns. If that sounds like a bit of a leap, consider that the US Olympic ski team increased their jump force by a mountainous 31 per cent after 11 days of neuropriming before training, while World Long Drive golf pro Mitch Dobbyn accelerated his club head speed by 5mph. The headsets are quickly gaining popularity, sported by NFL and NBA players looking to get ahead of the game, but they're not solely the preserve of elite athletes – members can borrow them for gym sessions at selected Equinox clubs, and the Halo effect is currently being researched independently for medical purposes.

The full benefits of breathing are only beginning to be explored

BREATHING

It's something that you probably do without thinking about it, which is precisely why experts are giving it more consideration. But breathing is also something that you can do consciously. It's being explored as a window to the autonomic nervous system, which controls many vital bodily functions (try to hold your breath and you'll eventually be overridden), and a means of modulating overactive fight-or-flight responses. Conscious breathing is a central tenet of ancient meditation techniques, and you instinctively know to take a deep breath when you feel stressed, but the mechanisms behind this age-old wisdom are now being looked at in detail.

In a study in *The Journal Of Neurophysiology*, both regulating breath by counting and paying attention to its automatic process influenced brainwaves in various regions, implying "a fundamental role of breathing-related oscillations in driving neuronal activity". Translation: where the breath leads, the brain follows. Most mind-bogglingly, Dutch researchers conceded that breath training, in conjunction with meditation and exposure to cold temperatures (taught by eccentric guru 'Iceman' Wim Hof), empowered subjects injected with a dead strain of *E. Coli* to fight off the infection more robustly, by apparently modulating their autonomic nervous and immune systems – something hitherto thought to be impossible. Aside from busting anxiety, boosting immunity and bestowing more oxygen for your body to play with, deep, diaphragmatic breathing from your abdomen is also blowing up with professional and recreational athletes because shallow chest breathing can cause physical tension in the upper body, so your posture and performance will suck.

SAUNAS

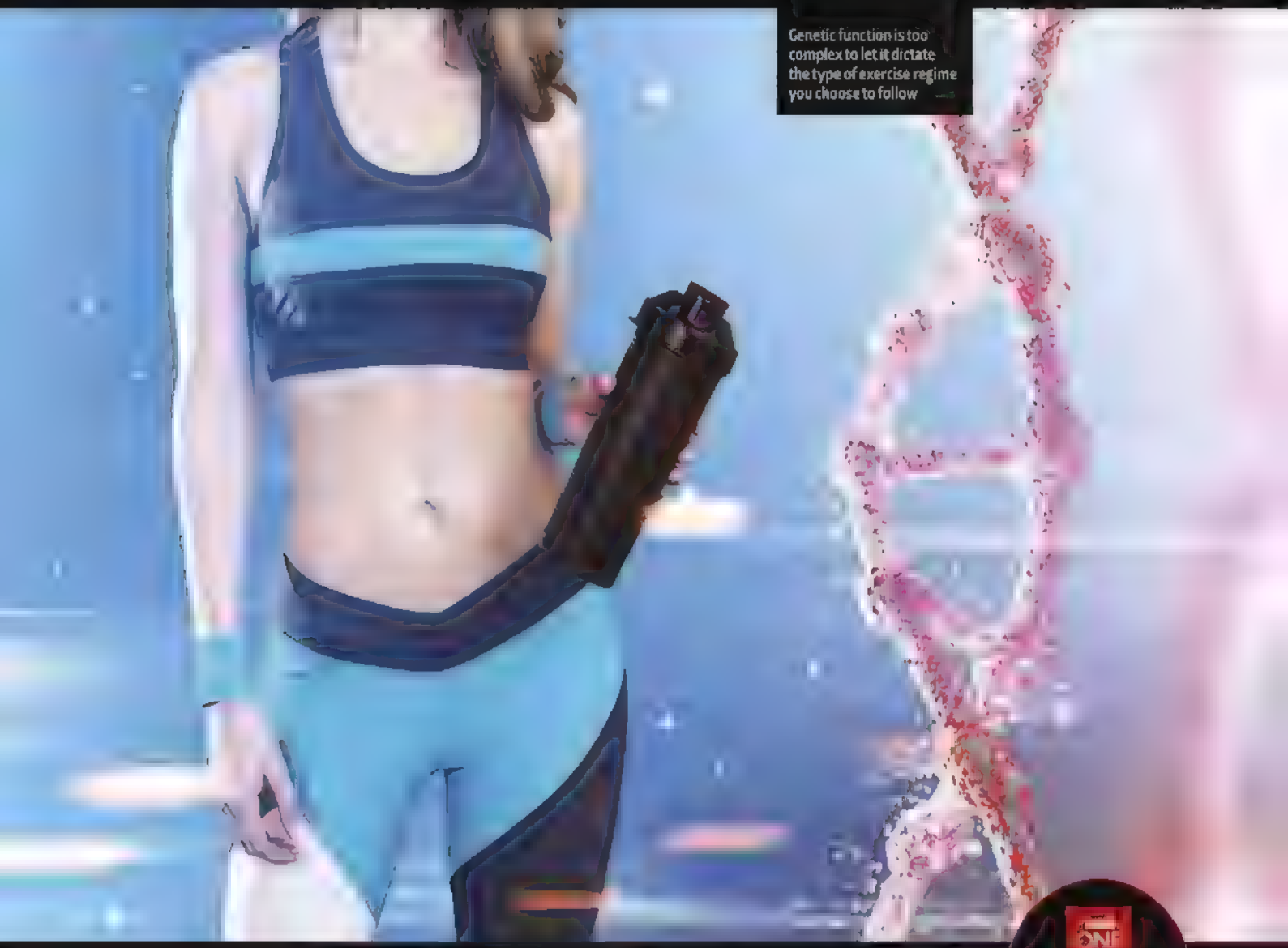
Getting sweaty at the gym without any effort is a hot topic at the moment. There is mounting evidence that spending time in a sauna can augment a workout, ameliorate the fallout and confer almost as many advantages in its own right (although you shouldn't take this as an excuse to skip the exercises).

Much of the new science is emanating from sauna-loving Scandinavia. The University of Finland revealed that half an hour lowers your blood pressure, improves vascular compliance – the ability of blood vessel walls to expand and contract with changes in pressure – and raises your heart rate on a par with moderate-intensity exercise. (The same research group has previously published a population-based study that associated regular saunas with reduced risk of hypertension, coronary disease and sudden cardiac death, Alzheimer's disease and dementia.)

Likewise, a Polish study pinpointed that alternate-day sauna-bathing lowered cholesterol "similar to the effect that can be obtained through moderate-intensity physical exercise".

Meanwhile, researchers at Korea University in Seoul discovered that raising your body temperature by 4°C after resistance training (with a heated blanket, but a sauna should do the trick) kindles anabolic or muscle-building hormones, resulting in increased muscular size and strength, to a greater degree than training alone.

Saunas: raising your temperature and possibly reducing your risk of coronary disease



Genetic function is too complex to let it dictate the type of exercise regime you choose to follow

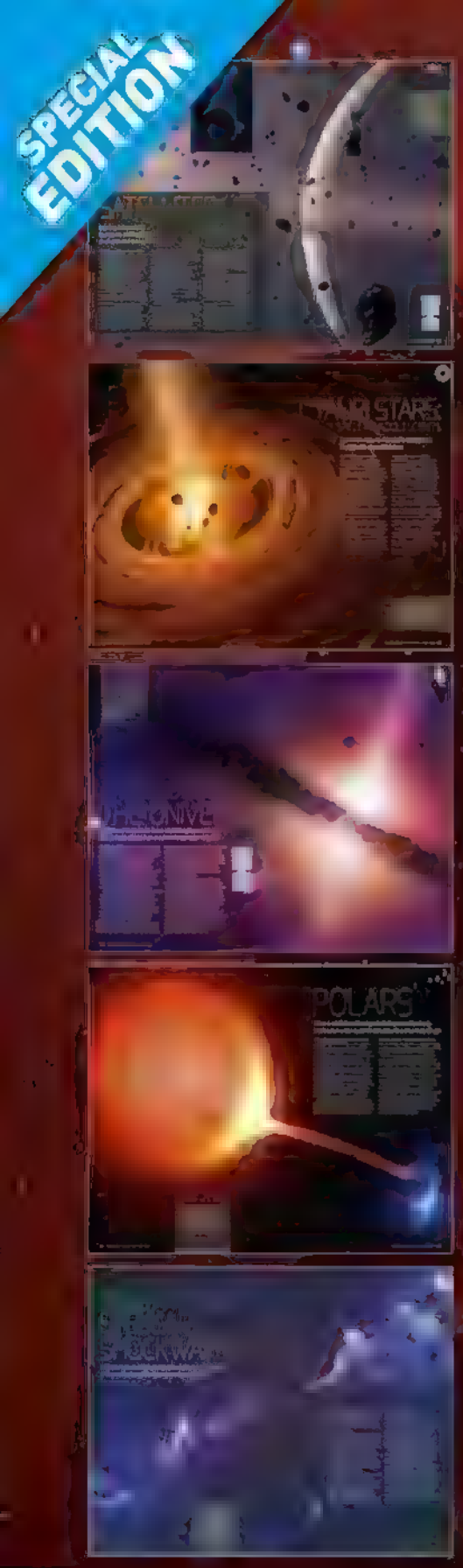
Watch *The Truth About Getting Fit* bbc.in/2uFTHrD

DNA WORKOUTS: DON'T BELIEVE THE HYPE

You'd be forgiven for thinking that there are as many direct-to-consumer genetic testing companies as there are different kinds of human genes (an estimated 20,000). The premise that you can tell from a sample of your blood, saliva or stool whether you're predisposed to strength rather than endurance training or vice versa is enticing. But such tests merely detect the presence or absence of a small number of genes that are only statistically associated with certain outcomes, and could be interacting with others in unseen and as not yet understood ways. A meta-analysis (study of studies) of the literature on nutrigenomics concluded that "solid scientific evidence is currently lacking", which echoes a statement from a group of leading academics in the *BMJ* in response to Brave New World-esque tests to identify children's athletic potential: "The general consensus among sport and exercise genetics researchers is that genetic tests have no role to play in talent identification or the individualised prescription of training."

Besides, just because you're not genetically predisposed to strength or endurance training doesn't mean you shouldn't do it. Even if the findings aren't entirely unfounded, they could still be a waste of money – a meta-analysis by Cambridge University deduced that giving subjects personalised genetic information about disease risk and lifestyle recommendations didn't make them any likelier to exercise more, eat better or stop smoking. SF

by JAMIE MILLAR
(@Mrjamiemillar) *Jamie is a freelance fitness writer*



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2

STRESS-PROOF YOUR LIFE

Got an endless to-do list? Heart racing? Dreading the 9 to 5? If this feels familiar, then it's time to take back control

words by SIMON CROMPTON
illustrations by JAMES MINCHALL

Every generation thinks it's the most stressed. In the 19th century, doctors warned that workload, education and too much information from newspapers was producing an anxiety-inducing cacophony of voices that was affecting the national well-being. Rest cures, nerve tonics, relaxation techniques and a kind of yoga were all the rage as cures for so-called 'nervous exhaustion'. Today, little has changed. In fact, the World Health Organization ▶

has labelled stress as "the health epidemic of the 21st century".

A long-running population study of women in Gothenburg, Sweden, found that in 1969, 36 per cent of them felt stressed, yet by 2005 the number had doubled to 75 per cent. Similarly, an analysis of self-reported data by Carnegie Mellon University in the US found that stress levels have increased by as much as 30 per cent over three decades.

Possible reasons behind these soaring stress levels are constantly being proposed: too many things to engage us from too many directions; increasing expectations of our productivity; 24-hour availability; the social pressures that information technology brings.

But research indicates a common thread: lack of control. The 21st century has seen a significant rise in situations where people have little autonomy but are under pressure to produce results quickly. In work, this type of stress has been found to reduce life expectancy. A 2016 study from Indiana University found that those in low-control, high-stress jobs have a 15 per cent increase in likelihood of death, compared to those with low job demands.

And the problem is that the more we move in stressful environments, the more

Research over the past 20 years is revealing increasing evidence of the dangers that long-term stress poses to our health

stressed we feel. A scientific study found that students who are taught by burned-out teachers display higher levels of stress hormones, such as cortisol, than their fellow students who are taught by calm tutors. It seems that 21st-century stress has all the qualities of an old-fashioned 19th-century contagion.

STRESS DAMAGE

So, if we are living in an age of anxiety, what's the effect on us? Doctors define stress as your body's response to mental or emotional pressure. That response centres on two adrenal glands sitting on top of each kidney. When we feel threatened, these glands release the stress hormones adrenalin and cortisol, which switch off the body's long-term repair projects in favour of short-term measures to help you deal with a crisis. They are the 'worry about the consequences later' hormones, increasing our heart rate and blood sugar levels to give us energy, but dampening down our digestion, our ability to rest and our immune response.

These effects are helpful in a short-term crisis – they helped our ancient ancestors to run fast if they were being chased by a wild animal. But in the modern era, where we aren't being chased by sabre-toothed cats, short bursts of stress can still be useful. A study from the University of Vienna indicates that humans are more likely to help others when under stress. The researchers scanned people's brains ➔

ARE YOU NATURALLY PRONE TO STRESS?

Everyone gets stressed, but some people seem more susceptible to pressures getting on top of them. It's not just a simple matter of genetics – although scientists have found genes that do seem to affect our ability to cope when the going gets tough. What's becoming increasingly clear is that stress in childhood can affect the way genes express themselves, and these epigenetic changes seem to be linked with conditions such as depression

Studies in animals are showing that stress in early life makes it much more likely that stress will prompt mood problems in adulthood. Childhood stress seems to trigger biochemical changes that alter the way genes express themselves. Once they've happened, these epigenetic changes can be passed down through the generations. So the stresses your parents or grandparents experienced in childhood may account for why you're easily wiped out by high-pressure situations.

while they were being stressed by time tasks and asked to respond to photos involving other people's welfare and pain. The team found that the neural empathy network reacted more strongly when under stress. Short-term stress might also make us temporarily more optimistic, as experiments have shown that we pay more attention to positive information and discount the negative when we're under pressure.

The problem is that modern stressors – from noisy neighbours to exam pressures – tend to be continuous rather than short-term. And research over the past 20 years is revealing increasing evidence of the dangers this long-term stress poses to our health.

Prof Stafford Lightman, an expert in stress-related disease at the University of Bristol, explains that if stress hormones like cortisol are raised continuously over say 24 hours, the responses it provokes can start to cause damage. "Cortisol is an anticipatory hormone, which is normally at its highest when you wake up, but you need a holiday from it so that the body can recuperate," he says.

Chronic stress has been linked to increased blood pressure, heart attacks, depression, teeth grinding, obesity, hair loss, acne, lowered fertility and some types of cancer.

"The mechanism by which chronic stress causes damage varies from tissue to tissue," explains Lightman. In the brain, for example, long-term cortisol exposure reduces the links between cells in the hippocampus. It also seems to affect the body's ability to regulate inflammation, particularly in the arteries, and this causes tissue damage and immune system disruption.

In 2018, medics demonstrated that people with higher activity in the amygdala – the instinctive part of the brain that signals the release of stress hormones – are more likely to experience heart attack, angina, heart failure, stroke and arterial disease. Their research, published in *The Lancet*, monitored the health and brain activity of 293 people over four years.

AND BREATHE...

It's perhaps no surprise that as awareness of the risks of stress are growing, many individuals are increasingly obsessed with attempting to stress-proof their lives. Meditation training is a booming industry. The Calm mindfulness app, which provides things like meditation tutorials and bedtime stories for adults, is valued at $1bn (approx £780m) alone. Many schools and employers are now routinely teaching their students and staff about time management, prioritisation techniques, mindfulness and yoga.

So do all of these stress management techniques actually do any good? Prof Marc Jones, a stress and emotions expert at Staffordshire University, says that there are certain techniques to help you deal positively with stress in the moment, and to help you relax between demanding situations so that stress does not become chronic. Both have a role. "Different things work for different people," he says. "What we've found is that people who feel challenged

Meditation training is a booming industry. The Calm mindfulness app alone is valued at $1bn

rather than threatened by a demanding situation, such as a test or a public talk, respond with increased cardiac output and blood vessel dilation. These people perform substantially better than those who have a threat response, where there is little or no change in cardiac output and blood vessels constrict. The challenge response is: 'It's difficult, but I'll do it'. The threat response is: 'I'm not sure about this, I want to avoid it'. What we've found is that physiological response consistently predicts how well people do in these demanding situations."

It is possible, he says, for all of us to learn mental techniques to help us feel 'challenged' rather than 'threatened'. "It's about focusing on what you can achieve rather than what might go wrong," he says.

So what might be the best ways of stress-proofing your life? On the following pages are 10 scientific approaches to dealing with stressful situations, and tips to give your brain time out of stress mode.

STRESS MYTHS: TRUE OR FALSE?

STRESS TURNS YOUR HAIR GREY

This is probably true. After all, we've seen political leaders go grey within weeks of taking office. The subject hasn't been studied much, but a paper published in *Nature* in 2013 did find that hormones produced in response to stress can cause the melanocyte stem cells that determine hair colour to leave our hair follicles.

STRESS WILL GIVE YOU STOMACH ULCERS

Nope. Common stomach ulcers are caused by an infection by *Helicobacter pylori* bacteria, not by stress. However, stress and other lifestyle factors, such as drinking alcohol and eating spicy food may make existing ulcers worse.

STRESS GIVES YOU WRINKLES

Probably true. At the end of our chromosomes is a protective cap of DNA called a telomere. Telomeres shorten as we age, and studies have shown that stress can prematurely shorten telomeres, speeding up the aging process. One study showed that long-term anxiety caused by phobias was linked with shortened telomere length, suggesting that stress might accelerate aging.

A POST-WORK DRINK HELPS YOU DE-STRESS

Wrong again. There's evidence that people who report high levels of stress tend to drink more. In the short-term, alcohol can help you relax and take your mind off troubles. But studies indicate that regularly using booze to de-stress has the opposite effect – your body becomes immune to alcohol's effects and stress hormone levels rise.

HOW TO BEAT STRESS

FORGET TAKING A CHILL PILL, THESE 10 SCIENTIFICALLY PROVEN TECHNIQUES WILL HELP YOU PROTECT YOUR BODY AND YOUR BRAIN FROM THE DAILY GRIND

1 TAKE CONTROL

"Perceiving that we have control over what might happen is a very important way for us to be able to deal with demanding situations," says Prof Marc Jones, a stress and emotions expert. "People often go into job interviews thinking they don't know what they're going to be asked, they don't know what they're going to say. Instead, think: what can I control here? Focus on the simple things you can control like how you walk into the room, how confident you appear. It's about building up our own resources to deal with stress differently." Research shows that this mental 'reframing' can genuinely help people's performance under stress. Jones's team at Staffordshire University found that the way a climbing task was verbally described to participants significantly changed how they approached the challenge: they did much better if it was made explicit that they had control of the situation.

2 CALCULATE THE ODDS

There are other techniques we can use to help improve our mindset when we get stressed. For example, Dr Frank Ghinassi, the head of behavioral health care at Rutgers University in New Jersey, recommends everyday tips such as calculating the probabilities of things actually going wrong instead of 'catastrophising'. If a worst-case scenario has a 1 in 10 chance of happening, then how much of your attention does it deserve?

3 SNACK ON FRUIT AND NUTS

Snacking on some fruit and nuts during the days when you're under stress may reduce the damaging effects it has on the body. Research has indicated that blueberries help counter the effects of PTSD in animals. And walnuts seem to prepare the body for stress, according to American researchers. They found that adding walnuts or walnut oil to people's diets reduced blood pressure responses to stress in the laboratory

4 WALK IN THE WOODS

People who live in more natural environments tend to have lower cortisol levels and fewer signs of chronic stress. Even if you live in the city, just getting out in the countryside can help. Japanese research on Shinrin-yoku ('forest bathing') has found that woodland environments lower cortisol, heart rate and blood pressure. "It's a pretty consistent finding that engaging with nature is a positive way to recover from stress," says Prof Jones.

5 GET YOURSELF A DOG

Dogs are great motivators for going outside and getting some exercise. But their company can also be a stress buster – especially for children. Children aged between seven and 12 have been found to get much less stressed about arithmetic and public speaking tasks when they have their dogs with them. Having a parent present did not have the same effect. Another study found evidence that owning a pet reduces blood pressure

BBC RADIO 4

Listen to an episode about stress on *All in the Mind*
bbc.in/2BP6TIh

6 HAVE A CUP OF TEA

It's the classic British response to a crisis: "Would you like a cup of tea?" And there is some evidence to suggest it provides more than a psychological boost. Research from University College London found that people who drink black tea become relaxed more quickly after a stressful task, and their cortisol levels return to normal at a faster rate. There is still uncertainty about which tea ingredient accounts for this. But separate Portuguese research has indicated that the weak concentration of caffeine found in tea reduces anxiety symptoms in mice!

7 PLAY VIDEO GAMES

There is evidence that playing video games can help reduce stress, which flies in the face of those who blame all our ills on screens. Cognitive psychologists at the University of Central Florida have shown that frazzled workers benefit more from playing a simple video game during a short work break than sitting in silence or taking part in guided relaxation. This is backed by studies indicating that military veterans who regularly play computer games as a means of escape tended to have served longer and cope better with physical and psychological stressors.

8 JUMP ON YOUR BIKE

It's boring but true: exercise reduces stress. In 2018, Canadian researchers reported that those who cycle to work display far lower levels of stress within the first 45 minutes of work than those who commute by car or public transport. Other studies have indicated that how stressed you feel in the early morning affects stress levels throughout the day. According to the Mayo Clinic in the US, exercise relieves stress by pumping up endorphin levels and forcing the brain to focus on movement alone.

9 GET HITCHED

Studies have found that the effects of stress are exacerbated if you're lonely. Engaging with other people, particularly loved ones, buffers stress and helps you break out of a personal perspective. For years, research has indicated that married people are generally healthier than single, divorced or widowed people, and now there's evidence that this is directly related to the lower stress levels they experience. Research at Carnegie Mellon University, in Pittsburgh, Pennsylvania, which was published in 2017, showed that married couples have consistently lower levels of the stress hormone cortisol. But any form of engagement with other people may help: research shows that social isolation is strongly associated with increased blood pressure as well as higher cortisol levels.

10 EAT PREBIOTICS

Prebiotics are compounds that promote the growth of good bacteria in the gut. Foods high in prebiotics include Jerusalem artichokes, chicory, garlic, leeks, onions, asparagus, bananas and whole wheat. Animal research has indicated that eating prebiotics prolongs REM sleep, which is believed to be essential for recovery from stress and stress disorders. This links with other research indicating that keeping your diet healthy and your gut happy helps to buffer stress. A study of 60,000 Australians, reported in the *BMJ*, found that people who ate five to seven portions of fruit and veg daily had a 14 per cent lower risk of stress than those who ate zero to four. SF

by SIMON CROMPTON
@simoncrompton7. Simon is a science and health writer

the PERFECT NIGHT'S SLEEP

How much shut-eye do we need? Do sleep aids really work? Discover the secrets to getting a good night...

words by SIMON CROMPTON

Even jellyfish need to sleep. Californian biologists monitoring jellyfish activity have found that these ancient species without brains fall into a quiescent state at the end of the day and release sleep hormones. The more sleep is researched, the more we discover that it is ingrained in millennia of evolution – for a purpose.

We know there is a close link between sleep and physical and mental health, and that lack of sleep affects our daily ability to learn and perform. In 2018, high-resolution brain images captured by electronic microscope revealed that the connections between brain cells (synapses) actually shrink during sleep to leave room for new growth and new learning connections the next day.

We're also painfully aware that sleep is important. A multi-million pound sleep industry has grown up around a society increasingly worried about tiredness, tempting us with thousands of sleep cures and gadgets (see 'Do sleep aids work?', right). Our obsession may be justified. Historical surveys suggest that today we sleep on average for around 6.5 hours – over an hour less than we did in 1942.

But we often approach our anxieties about sleep in the wrong way, say sleep experts. We go for quick fixes backed by little scientific evidence when we should be taking sleep more seriously: each of us working out our sleep needs and then working out how we can change our lives to meet them.

On average, we sleep for around 6.5 hours – an hour less than in 1942

How much shut-eye do we need? There are some general pointers. Preliminary results from the world's largest sleep study, published in October 2018, showed that people who sleep on average between seven to eight hours per night performed better cognitively than those who slept less, or more, than this.

However, Professor Derk-Jan Dijk, Director of the Surrey Sleep Research Centre, says we all have different needs – some people need seven hours, some need nine hours. "People aren't always good at estimating how much sleep they need, but in a way we know. The key is to ask yourself whether you are sleepy in the day. If you are, you need more."

Connections between our brain cells shrink while we sleep creating space for new growth the next day

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"People need to figure out what's happening. What is it in my lifestyle or environment that's stopping me sleeping well? When am I most stressed? Is coffee or wine in the evening, or snoring, a problem? The secret to a perfect night's sleep will be different for each individual."

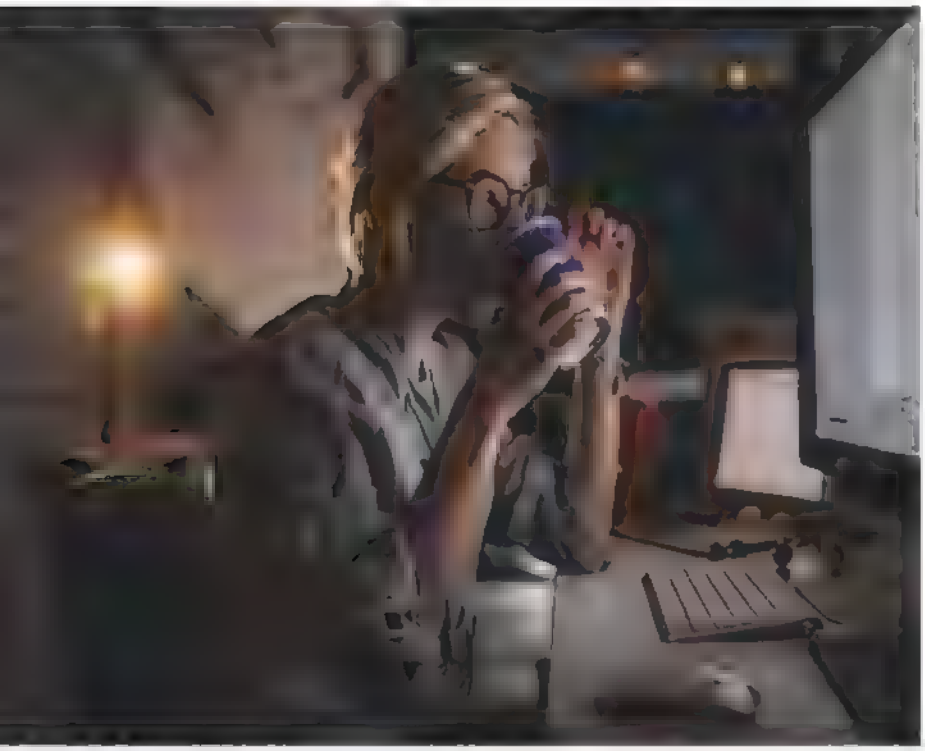
ADDRESS STRESS

Several studies have indicated that people who have stressful events in their life, such as the loss of a spouse, are more likely to have sleep disturbances that increase inflammation levels in the body. These elevated levels of inflammation may increase risk for cardiovascular illness.

Sleep and stress are closely linked, stress causing insomnia and insomnia causing stress. Derk-Jan Dijk says the main reason most people can't sleep is 'rumination' – thinking and worrying about what's happened and is about to happen. This is why some experts recommend unloading such worries before you go to bed with 'to-do' lists. The irony, however, is that the thing some people worry about most is being unable to sleep.

"People think that if they have a poor night's sleep, they won't be able to function the next day," he says. "They start catastrophising, and this has a negative effect on sleep itself. But one poor night's sleep isn't going to kill you. If you normally sleep seven hours, and only

People who sleep 7-8 hours a night perform better cognitively than those who sleep less, or more, than this



DO SLEEP AIDS WORK?

In 2017, economists estimated the sleep aid industry to be worth $30 billion (£23bn) globally. We're talking sleep apps, melatonin tablets, eye masks, ear plugs, herbal infusions, oil diffusers, sleep monitors embedded in mattresses, spooning robots, even LED lights in the toilet to aid night-time loo visits without disrupting sleep hormones.

But do any of the products work? Though many are fun, and some may help some people, sleep scientists are generally sceptical. Alice Gregory, Professor of Psychology and co-head of the sleep lab at Goldsmith's, University of London, thinks evidence for the claims made is often scanty – and should be examined before purchasing. "I also wonder whether some products may contribute to difficulties sleeping," she says. "Sleep should be automatic and not contrived. If we start to focus on it too much, this can cause problems."

Colin Espie, Professor of Sleep Medicine at Oxford University's Nuffield Department of Clinical Neurosciences, says there is very little clinical validation for anything on the market. "They are pretty much digital toys," he says. "Sleep monitors and sleep apps, for example, may claim to provide feedback on how you have slept, but there is little evidence that this information is founded upon their actual sleep. You may have slept better, or worse, and almost certainly differently from what the device is saying. Accuracy matters."

FIVE THINGS TO AVOID FOR A GOOD NIGHT'S SLEEP

COFFEE

Studies show that the caffeine in strong coffee will keep you awake or disrupt sleep even if you drink it six hours before bedtime. But research indicates that night owls are less affected than morning larks.

ALCOHOL

Alcohol disrupts the normal production of chemicals to induce sleep, blocks restorative REM sleep and makes night-time breathing more difficult. A study from the University of Missouri-Columbia indicates that just one binge-drinking episode can alter a gene that regulates sleep.

PAINKILLERS AND COLD REMEDIES

Many 'plus' or 'extra' varieties of pain and cold medications based on paracetamol or ibuprofen contain caffeine to make you feel more alert. Look out for the decongestant pseudoephedrine in cold remedies too: this can cause wakefulness.

NICOTINE

Nicotine is a stimulant, so whether you get it through smoking, gum or vapes it can disrupt sleep and reduce total sleep time. Research found that smokers are more likely to report poor sleep quality.

CHOCOLATE

The National Sleep Foundation in the United States recommends not eating chocolate (milk or dark) before bed. Yes, it contains some caffeine, but it's the presence of a compound called theobromine, which increases heart rate, which is most likely to keep you awake.

get five because you woke up in the night, it doesn't mean you won't be able to do your job."

PREPARE YOUR BEDROOM

Matthew Walker, Professor of Neuroscience and Director of the Center for Human Sleep Science at the University of California, and author of *Why We Sleep: unlocking the power of sleep and dreams*, says that darkness and the correct bedroom temperature are crucial for getting to sleep.

"We are a dark deprived society and we need darkness to release melatonin that helps the timing of your sleep," says Walker. He recommends a cool bedroom temperature of 18.5°C. "It's colder than most people think, but your body needs to drop its temperature by about one degree to initiate sleep and that's the reason you'll always find it easier to fall asleep in a room that's too cold than too hot."

Also make sure that you don't lie in bed awake too long, he says: your brain learns an association that being in bed is about being awake rather than asleep.

DIM THE LIGHTS

Research has confirmed the importance of a part of the brain called the suprachiasmatic nucleus (SCN), a group of cells that responds to light signals from the eye. When it's light, the SCN messages other parts of the brain to release hormones which make us feel alert, and when it's dark it signals for the release of hormones that make us feel sleepy.

If our habits are regular, then our brain adjusts to release hormones at the right time. If they're not, we end up in constant conflict with our natural circadian rhythm.

Having bright lights on in the evening, and being exposed to the blue imitation daylight emitted from computer screens, confuses our SCN further. Our brain is tricked into thinking it's day when it's not, and we end up alert when we should be sleepy. That's why sleep experts recommend dimming the lights and ending screen time a couple of hours before bedtime.

Research from the University of Kent suggests that one of the reasons that older people find it harder to get a good night's sleep is that age

Experts recommend ending screen time a couple of hours before bedtime

GETTY IMAGES

Above: Young people who are lonely are 24 per cent more likely to have poor sleep quality

impairs the body's internal clock to re-set itself when exposed to daylight.

BE ACTIVE

Getting out and about during daylight hours is not only good for resetting the body clock. Exercise independently improves the ability to sleep – just as a good sleep improves your ability to exercise. According to the Johns Hopkins Center for Sleep in the US, the effects of aerobic exercise are similar to those of sleeping tablets.

ORGANISE SLEEP TIME

Many of us simply need to carve out enough time for sleep from our daily routine. Derk-Jan Dijk says that when people intend to get eight hours sleep, they end up only getting up off the sofa at 11pm for a 7am rise. "They forget about locking up, brushing their teeth, putting on their pyjamas, having a last look at their phone. By the time they're ready for sleep it's 11.30pm."

CONSIDER YOUR GENES

Some of us are just born more likely to suffer from insomnia than others. One study, published in the journal *Molecular Psychiatry*, claims to have identified specific genes that may trigger the development of sleep problems. Another study, from the Society of Neuroscience, shows that patterns of electrical activity generated by the brain during sleep are inherited.

MEET SOME FRIENDS

Research from King's College London has found that young people who are lonely are 24 per cent more likely to have poor sleep quality and feel tired during the day. Whether it's loneliness causing bad sleep or vice versa, however, is open to question. Another study from the University of California, Berkeley, has found that the brains of sleep deprived people shut down the areas that encourage social interaction.

ADDRESS INSOMNIA

"Around 20 per cent of your readers are likely to have a serious sleep problem," says Colin Espie, Professor of Sleep Medicine at Oxford University's Nuffield Department of Clinical Neurosciences. According to Espie, a serious problem constitutes difficulty sleeping for three or more nights per week for three months or longer.

In such cases, Espie and other sleep scientists recommend a cognitive behavioural therapy (CBT) approach. This means challenging and correcting thought patterns that may be causing sleep problems. For example, providing information about the science of sleep can reverse incorrect beliefs which are affecting sleeping habits.

Guidelines produced by the American College of Physicians have declared CBT to be the best first line of treatment for chronic cases of insomnia in adults. And there is robust evidence that digital CBT software, such as the Sleepio package, is effective at tackling long-term sleep problems. Sleepio is available through the NHS in some parts of England. **SF**

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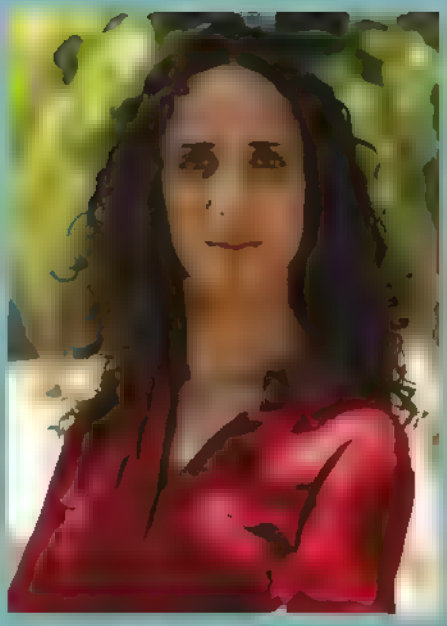
by **SIMON CROMPTON**

(@Simoncrompton2) is a science writer specialising in health, and formerly a medical editor on The Times

WHAT MAKES US TICK?

Ella Al-Shamahi tells us why we need to listen to our body clocks

Everyone on Earth marches to the same beat: our bodies have an internal clock that keeps us on a 24-hour cycle. It's fundamentally important for our sleep pattern, but it's also linked to everything from our hunger and metabolism to our heart function, mental health and immune system. Evolutionary biologist Ella Al-Shamahi (right) looked into our sense of time for an episode of BBC Two's *Horizon*, and showed how we can hack our body clocks... with the help of a former Commando who spent 10 days locked in a nuclear bunker.



"The brain uses nerves and hormones to transmit this 24-hour rhythm to our internal organs"

WHY DID YOU LOCK SOMEONE IN A NUCLEAR BUNKER?

Because we live in this modern, technological world, none of us really realises how powerful our body clocks are, or the factors that affect them. So we put Aldo Kane, a former Royal Marines Commando, in an underground nuclear bunker, with no access to sunlight and no way of telling the time, to see what effect that had on his body clock.

WHAT EXACTLY IS THE BODY CLOCK?

It's our internal clock that keeps all our body functions in sync. It's regulated by a tiny region in the brain located in the hypothalamus, and it takes its cues from the day-night cycle of sunlight. The brain uses nerves and hormones to transmit this 24-hour rhythm to our internal organs, which helps to tell our body when it needs to eat, sleep, wake and work. As an evolutionary biologist, the really interesting thing for me is that the body clock is a highly 'conserved' mechanism, which means that it's stuck around for a long time in evolutionary terms – millions and millions of years. If something is highly conserved, that usually means it's pretty useful.

WHAT DID THE BUNKER EXPERIMENT INVOLVE?

There were three phases. In phase one, for the first few days, we didn't do anything other than just put Aldo down there and monitor him while he went about a normal daily routine – eating, sleeping, exercising, reading. We didn't give him any indication of what time it was. He wasn't getting any natural sunlight, of course, but he could control the lights in the bunker, so when he woke up he'd put all the lights on, and when he went to sleep, he'd switch them off again.

The second phase of the experiment was what we called 'going dim'. We turned off all the lights, and left only a dim lamp for Aldo, so he was pretty much in darkness for a few days. We wanted to find out how his body clock coped when there was no light at all.

And then in the third phase we put Aldo into jet-lag mode. Usually, when you get jet lag – perhaps when you're flying from New York to London – you have one disrupted sleep, but then you make up sleep over the next few days. But we woke Aldo up in the middle of his sleep at the same time for several days in a row, keeping him in constant jet lag. We weren't really giving him a break.

HOW DID HE COPE WITH ALL THIS?

Not well! He was losing track of time – he thought it was a completely different time to what it actually was. And in the third stage, we were forcing him to wake up, so that kind of messed with him. He's someone who's tough, which is why we chose him for the experiment, but he was clearly losing it. It was partly the lack of contact with other people. But it was also clearly the fact that his body clock was out of sync. He was really miserable by the end of it.

WHAT DID YOU FIND OUT?

In the first phase, even though Aldo had no way of knowing the time, his body clock still broadly kept to a 24-hour cycle. He wasn't suddenly shifting to 36 hours, or 12 hours for that matter. So it's not your watch, or your ➤

phone or the outside environment that's controlling that – your internal clock keeps its own time. But we could see that his sleep was shifting later and later.

When we turned off the lights in phase two, we saw that shift in Aldo's sleep pattern even more. Without any light, his body clock really struggled to keep time – it entered a stage called 'free running', which I think is a really great term. Essentially it's where the body clock runs away with itself. We aren't sure why, but most people's clocks run slightly longer than 24 hours, and this is what we saw here. We need light to 'reset' and recalibrate our body clocks.

I asked Aldo before he went in what time he normally woke up, and he said six o'clock every morning, with or without an alarm. I thought that was really interesting because here was somebody whose body wakes him up at six o'clock every day, but suddenly, when we took away his access to sunlight, he was shifting later and later. By the end of the experiment he was over three hours out of sync with the outside world. It's like those old winding clocks – you need to recalibrate them every day just to make sure that they're telling the right time.

When we were filming, I also meet a man called Mark Threadgold who lost his sight while serving in the British Army. Most blind people have some kind of light perception, but Mark's optic nerve was severed, so he doesn't see any light at all. He is constantly in that free running phase. Every day, he loses about an hour of sleep, so in the space of a month he does a full circle. He described how lethargic he was, and how it was really bad for his mood, so it really brought home the kind of impact this can have.

HOW CAN WE APPLY THESE FINDINGS TO OUR DAILY LIVES?

What we put Aldo through was an extreme situation, but modern living is also quite extreme from an evolutionary perspective, in that a lot of us spend our days without much natural sunlight, which is something we're not designed for. So some of the advice is simply to find ways to increase your exposure to natural light: maybe you can cycle to work instead of getting the train, or you could try to take a little walk outside during your lunch break.

> "Just as our bodies have an overall 'master clock', different organs also have their own clocks. So your ability to do certain things is governed by the time of day"

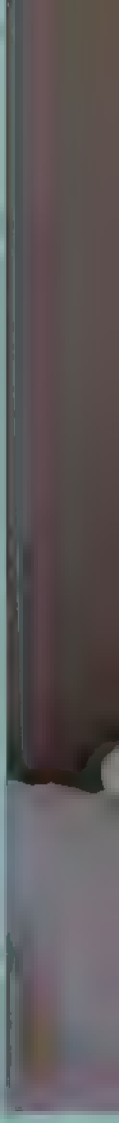
Another interesting thing I found from talking to the researchers in the programme is that, just as our bodies have an overall 'master' clock, different organs also have their own clocks. So your ability to do certain things is governed by the time of day. We saw this with Aldo in his tests in the bunker.

I had always thought that you're supposed to workout first thing in the morning but, the truth is, I've never really been much good at doing that. It turns out that it's not just me. In the morning, our bodies are still waking up, so it's best to wait until later in the day to workout. The morning is a good time to eat a big meal, though, because our metabolisms are more efficient then. It's better not to eat a big meal at the end of the day. So our digestive systems have a body clock, too.

IS THERE ANY WAY TO COMPLETELY RE-TUNE OUR BODY CLOCKS?

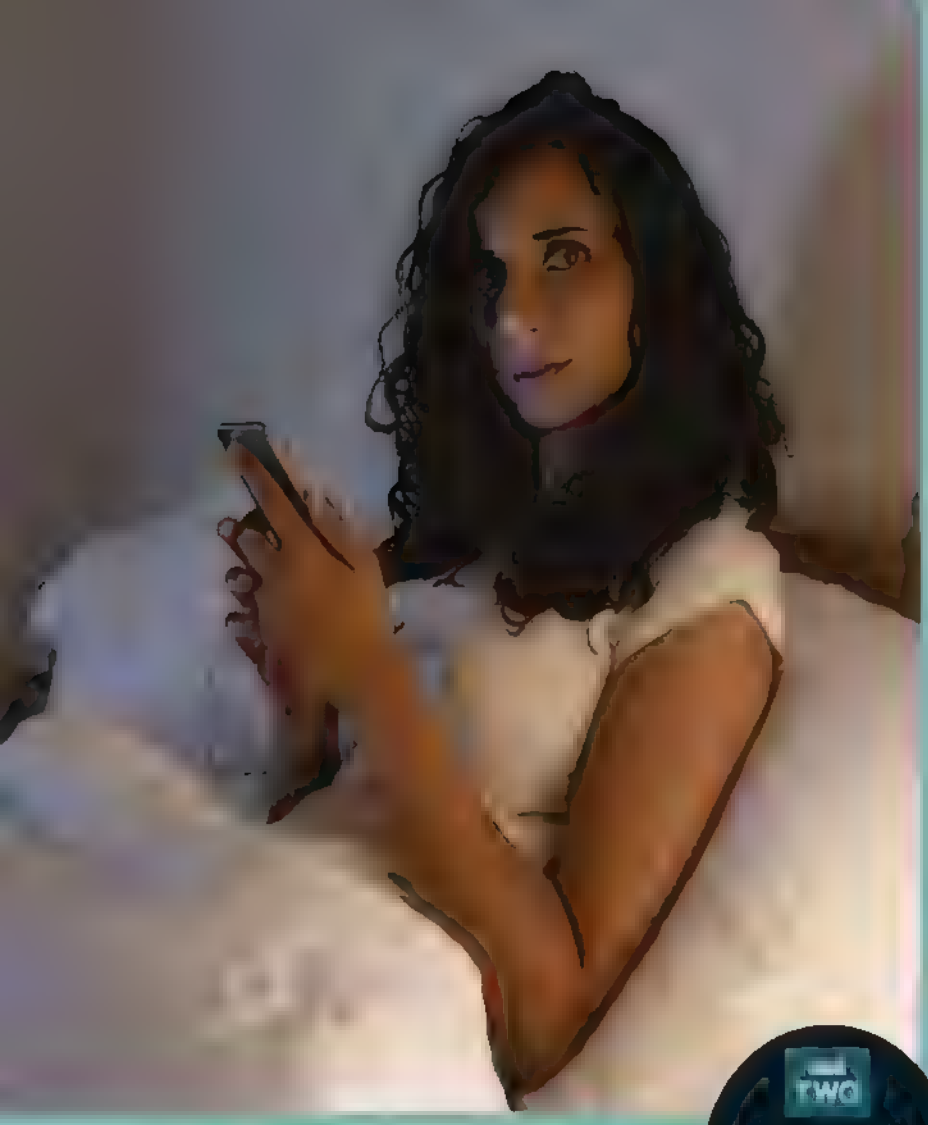
For the *Horizon* programme, I met a couple who were struggling to synchronise their body clocks. Naomi is an early bird, while Greg is a night owl. They go to sleep together, but then Greg just faffs around in bed for hours until he finally gets to sleep. They really want to address that difference, because it disrupts Naomi's routine too, and they are getting married.

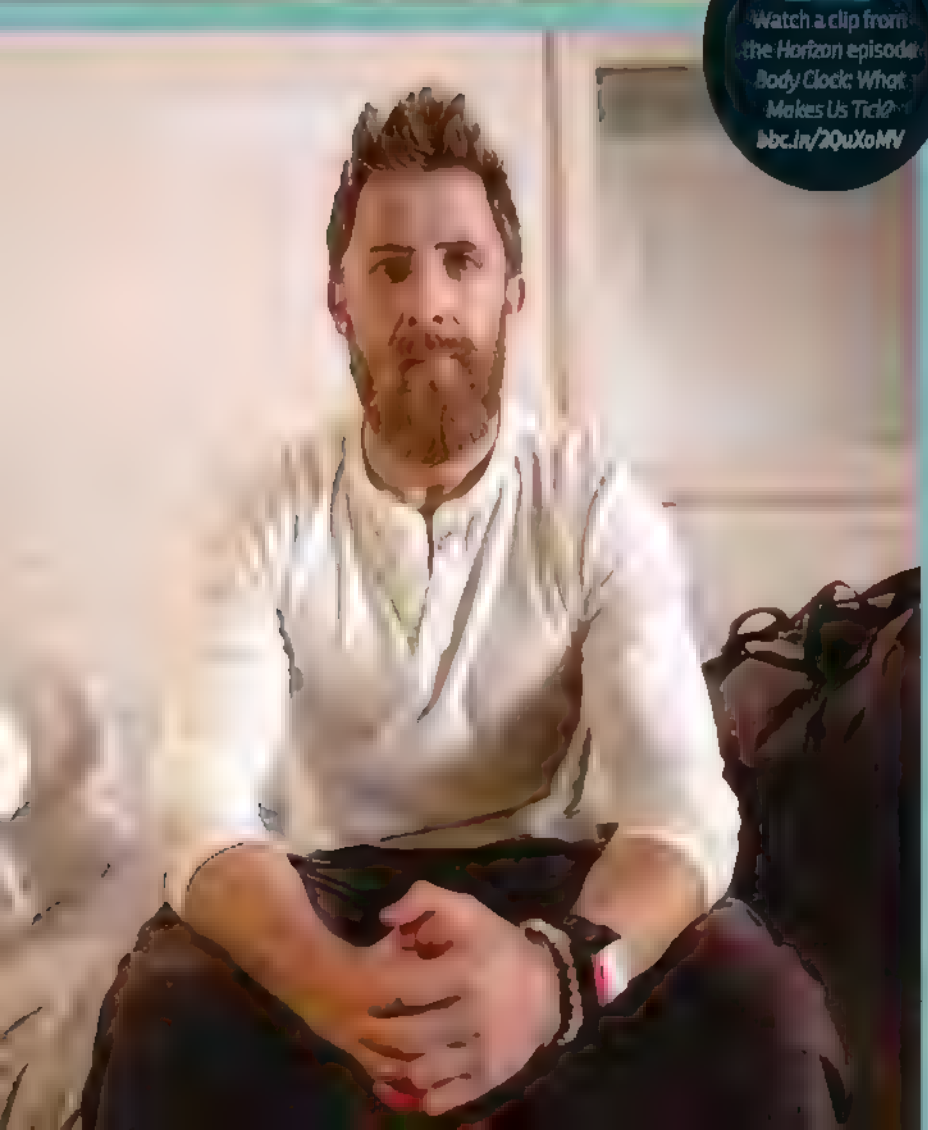
In a way, Greg is completely normal. Around 25 per cent of the population are night owls, while 25 per cent are early birds, and the rest are somewhere in between. We can't radically change where on the early bird/night owl spectrum we fall, but it is possible to shift our body clocks in a particular direction. Greg wanted to shift his body clock a bit earlier to



Ella s earned that there are ways to reduce the effect late-night phone use has on our sleep patterns but the best approach is not to use them in bed at all

Former Commando Aldo Kane volunteered to be shut in a nuclear bunker without access to natural light for *Horizon*'s body clock experiment





match his partner's. So the sleep scientist in the programme gave him goggles that cut out blue light in the evenings (these fool the body clock into thinking it's darker than it is). In the old days, if you wanted to work into the night, you had to light a candle. So you were already preparing yourself to go to sleep, whereas now you can have bright lights on up until the very second that you fall asleep.

Greg also started going outside more during the day to get that sunlight. If you're a night owl, you want to be getting outside in the morning sunlight, whereas early birds can shift their sleep a bit later by getting more sunlight in the afternoon. With Greg, the changes really had a positive impact.

WHAT OTHER TIPS DID YOU PICK UP?

To help your body clock keep a regular rhythm, aim to go to bed and wake up at around the same time every day. Try not to use your phone at night, but if you have to, use a night mode or blue-light filter.

I met another couple in the programme who both work night shifts – one of them really struggled to go to sleep, and the other one would sometimes sleep for 24 hours in one go. We sat them down with a researcher, who explained that they really need to be sticking to the same sleeping pattern every day, even on their days off. Keeping to the same timetable is much better for the body clock.

Something else that came up while making this film is the fact that most jobs are nine-to-five. But those hours are just not going to work for some people. If you're a night owl, it's no good expecting to be productive at nine o'clock in the morning. It'd be great to move to a society where people can be flexible in their working times so that they can work to a schedule that suits them.

HAVE YOU CHANGED ANY OF YOUR OWN HABITS?

My sleep is generally terrible and I don't respect my body clock at all, so I became slightly mortified at the impact I was having on my own health. I'm not a shift worker, but my sleep resembles one. I work really strange hours. So I'm now trying to stick to the same sleep routine every day. **SF**

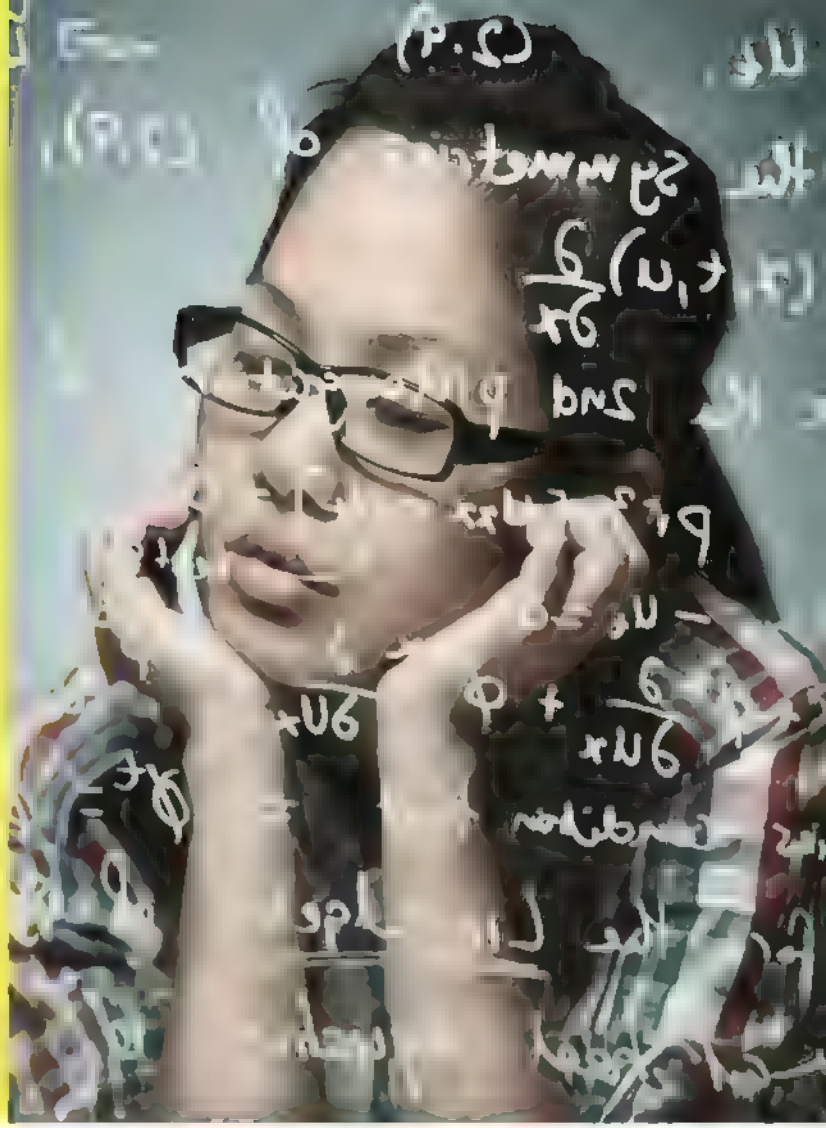
The surprising NEW SCIENCE *of* SLEEP

YOU SPEND A THIRD OF YOUR LIFE IN BED (IF YOU'RE LUCKY), BUT SCIENTISTS ARE ONLY JUST BEGINNING TO UNDERSTAND WHAT GOES ON BETWEEN THE SHEETS. WE REVEAL THE UNEXPECTED DISCOVERIES BEING MADE IN THE DEAD OF NIGHT

ALICE GREGORY

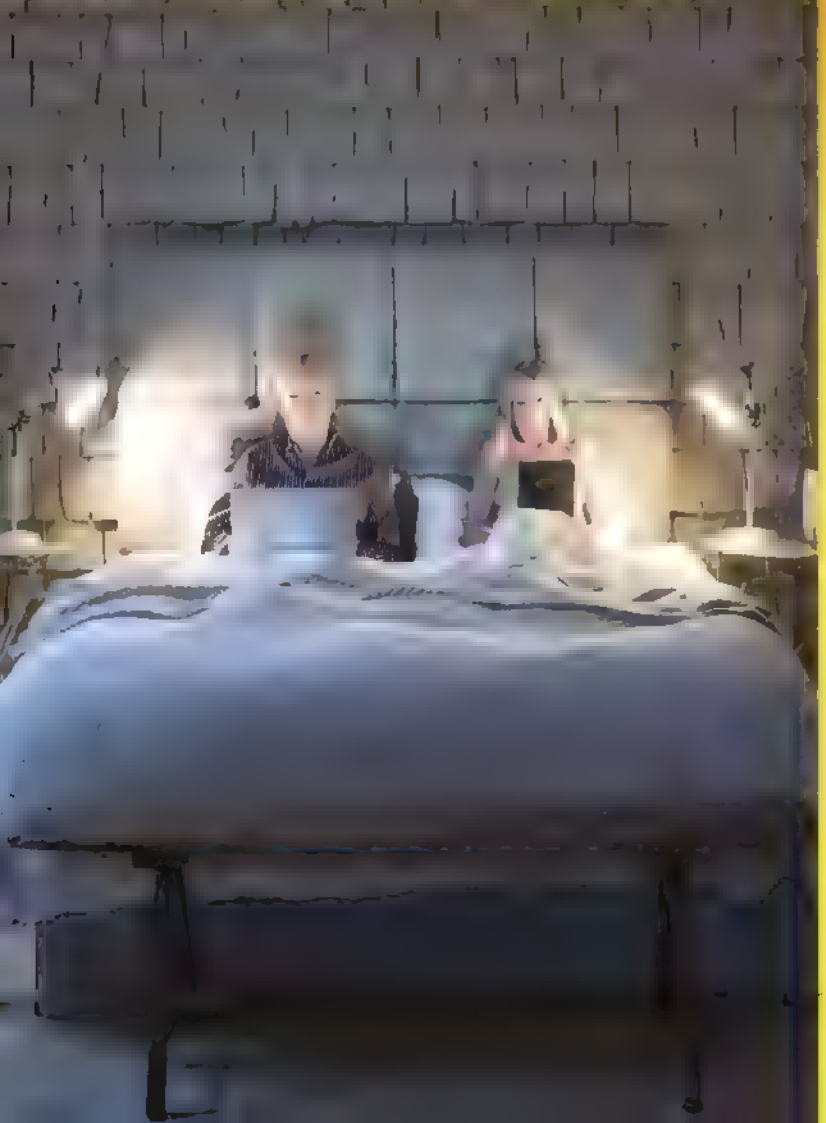
WE CAN LEARN IN OUR SLEEP

Scientists know that weak traces of memories established during our waking lives are made more stable and enduring while we sleep. Yet what is perhaps less well understood and much more controversial is that we might be able to learn new information while we snooze. An example of this comes from a study in New York that focused on newborn babies. While they slept, a musical tone was played, then air was puffed towards their eyes. The babies soon came to expect the air puff, and would move their eyes upon hearing the tone. However, this was a simple example, and it is unlikely that more complex information could be learned in this way. What's more, numerous attempts to teach people new information during their sleep at other stages of life and using different experimental designs have largely failed. While sleep is clearly important for our learning and memory, frantically playing audiobooks the night before an important exam is not going to improve anyone's results. Sorry about that.



MORE SLEEP ISN'T ALWAYS BETTER FOR YOU

It's becoming clear that we need enough sleep to make the most of our time awake. There are recommendations for the amount of sleep we should get at different stages of life, with experts suggesting eight to 10 hours for teenagers, and seven to nine hours for adults. But is it a problem if you get *more* than the recommended amount? A number of studies have highlighted associations between long sleep (which is defined in different ways, in different studies) and various problems such as obesity, cardiovascular disease and even early mortality. There's a number of possible explanations for why too much sleep might be linked to problems like these. Sleeping for excessive periods can be a sign of certain mental and physical disorders. Furthermore, when we're in bed excessively, our sleep can become more fragmented, so we may not get enough good-quality sleep. So does this all mean that long sleepers should restrict their time in the land of nod? That does not seem to be the case, according to the data we have to date. However, researchers need to establish why these associations exist if we want to use this information to improve our health and well-being.



SLEEP CAN HELP TREAT MENTAL HEALTH

We've known for a long time that disturbed sleep can be a feature of various psychological disorders. For example, insomnia (difficulties nodding off or staying asleep) and hypersomnia (excessive sleepiness) are listed among the criteria for diagnosing depression.

What's more novel is that addressing sleep problems might help prevent or resolve other psychological difficulties. Studies looking at children who are experiencing sleep-disordered breathing, for example, have found that removing adenoids and tonsils to improve night-time breathing is linked with fewer symptoms of attention deficit hyperactivity disorder (ADHD). Likewise, a study led by researchers from the University of Oxford found that when insomniac students were given cognitive behavioural therapy (CBT) along with standard treatment, they experienced reduced insomnia, paranoia, hallucinations, anxiety and depression, compared to those who did not receive CBT.

OLDER PEOPLE ARE LESS AFFECTED BY BLUE LIGHT

Blue light is what you see outside on a bright summer's day. But it's also the light that many smartphones and tablets emit. It's been given particular attention recently because it can suppress the hormone melatonin, which our bodies produce when the Sun sets to make us feel sleepy. Therefore, if we look at the blue light of our tablets late at night, our bodies might be missing a cue that it is time to sleep. The upside of blue light is that it can be helpful at certain times of day, increasing arousal and alertness when needed and helping to set the body clock.

But it seems that the effect of blue light might vary at different stages of life. For example, the lenses of the eyes can yellow over time due to the accumulation of pigment, which can lead to less blue light being passed to our retinas. But before any older adults out there use this as an excuse to start playing with their tablets in bed, remember that engaging with these devices is likely to lead to wakefulness, which makes it difficult to justify as a bedtime activity.

SLEEP DISORDERS COULD EXPLAIN ALIEN ABDUCTIONS

Sleep research could explain the paranormal. Someone might describe waking up at night to find they are unable to move, often with a strong sense that something, like an alien or demon, is present. Scientists think 'sleep paralysis' might explain these experiences. During an episode of sleep paralysis, we may wake up and open our eyes, but certain normal features of REM sleep – such as paralysis and dreams – continue. Sufferers of a condition known as 'exploding head syndrome' have also been known to attribute the experience to the paranormal. This typically involves someone hearing a loud noise just as they are falling asleep. The most likely explanation is that when we fall asleep a part of the brain called the reticular formation inhibits our ability to hear, move and see. But in the case of exploding head syndrome, the auditory neurons fire up instead of shutting down, leading to banging noises.

SLEEP IS A COMMUNAL ACTIVITY

Many of us think of sleep as a solitary pastime, particularly researchers, who tend to study people sleeping alone in labs. But, there are many reasons to think of sleep in the context of our families and communities. For example, most adults sleep with someone else, so in order to fully understand someone's sleep patterns you need to think about their partner's nocturnal habits too. Likewise, children's sleep patterns can only really be understood when we look at the bedtimes that parents set, and whether they expect their children to sleep through the night.

Our sleep timing changes throughout our lives, with adolescents tending to stay up late and older adults going to bed early, for example. It's thought this may be a legacy from pre-civilisation to ensure that someone is always awake to help keep a lookout for the group – it makes sense to only sleep if we feel safe. In fact, loneliness has actually been linked to poorer sleep. A similar explanation has been provided to account for the genetic differences that are associated with sleep timing (whether we are an early bird or a night owl). **SF**

ALICE GREGORY *Alice is Professor of Psychology and co-head of the sleep lab at Goldsmiths, University of London*

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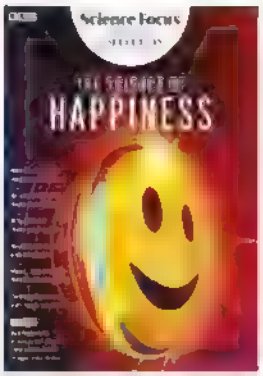

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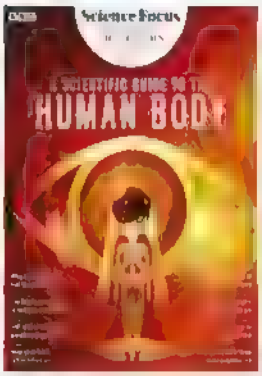

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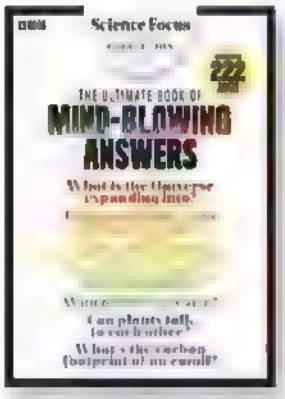

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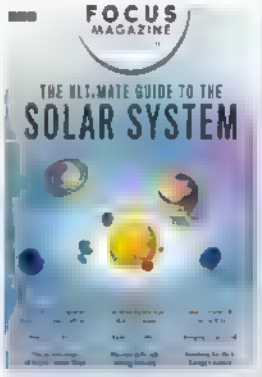

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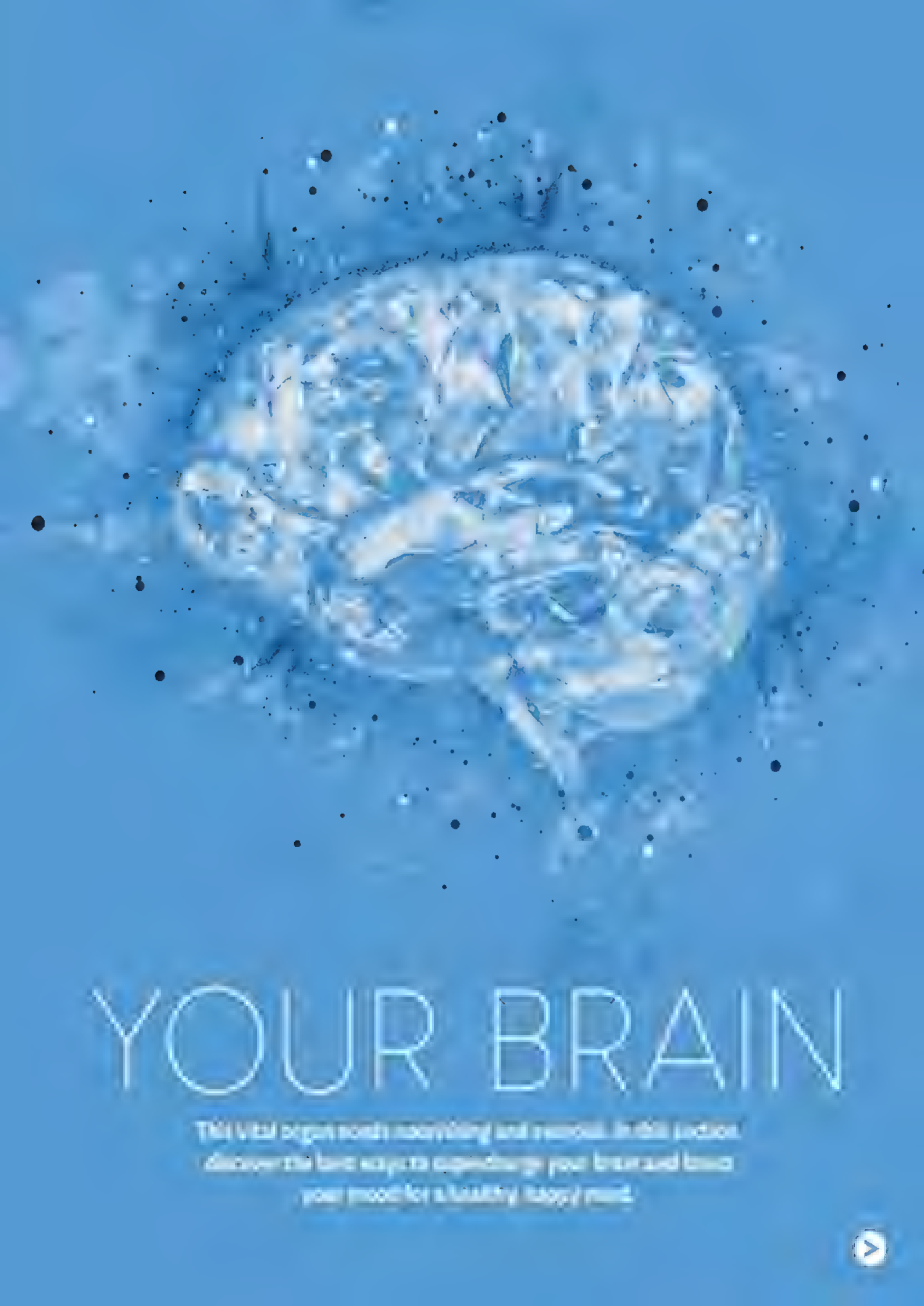


YOUR BRAIN

BRAIN BOOSTERS

The brain-training industry is booming. But do games and other brain-stimulating devices really work?

words by RITA CARTER

Multi-coloured bubbles bob across your screen. Senses tuned, finger hovering on the track-pad, you spot the pink one and direct the cursor. BAM! An exploding star announces you have beaten your all-time record – your ability to shoot pink bubbles is getting better and better.

When you end the game, though, will you also be better at driving your car, cooking dinner or giving a presentation? Or are you just getting really good at shooting pink bubbles?

If you ask Google whether brain-training games do anything other than make you good at doing them, you'll come across dozens of 'conclusive' studies showing that they do. You'll also find as many, equally conclusive, studies showing that they don't.

The lack of clear yes/no evidence has not stopped the brain-training industry from rocketing. Dozens of online sites and downloadable apps promise you will improve your cognitive skills by playing their computer-generated games. You can also buy brain-stimulating devices, a dizzying variety of 'smart' drugs or sign up to learn mental practices such as mindfulness meditation. The brain fitness market is already generating more than $2 billion (£1.6bn) globally and is predicted to grow to more than $8 billion (£6.4bn) in the next couple of years, making it one of the fastest growing industry sectors ever.

A few landmarks stand out in the ocean of conflicting literature on cognitive training.

In 2010, a big study of 11,430 healthy volunteers under 50 showed that six weeks of practising a specific set of brain-training games made participants better at playing those specific games, but didn't noticeably improve their functioning in everyday life.

This was followed in 2014 by a 'position statement' issued jointly by the prestigious Stanford Center on Longevity and the Berlin Max Planck Institute for Human Development. It asserted there was little evidence of efficacy for commercial brain training and triggered several lawsuits against training companies who were judged to have made excessive claims.

And yet several subsequent studies have found a knock-on effect of brain training for older people, and in 2016 a group of 111 senior scientists issued a statement claiming it can have general benefits. It cited a slew of randomised clinical trials in support.

The academic wrangling continues. 'Take this Cognitive Training Efficacy Bar Fight Outside' begged the title of one commentary in a journal. The author, Prof Richard Keefe of Duke University School of Medicine, explains that the headlines that emerge from studies fail to convey the devil that lies in the detail. "[The controversy has] left the public with the impression that all computerised cognitive training products are ineffective and worthless. As a result, they may not be used nearly as frequently as they should by the people ➔

The brain fitness market is predicted to grow to more than $8 billion globally in the next three years

Brain training helps make up for a lack of intellectual challenge after retirement

GETTY IMAGES, ALAMY

who need them."

Professor Keefe would like to see the fight adjudicated by a regulatory authority which would issue clear guidelines about who could benefit from brain training. So far, though, this has not happened.

LIFE TRAINING

Further complicating matters was another long-term study published in the *BMJ* in 2018. Led by Dr Roger Staff from the University of Aberdeen, the findings suggested that although doing puzzles has no effect on mental decline through age, regularly pursuing 'intellectual activities' throughout your life may raise your cognitive abilities to a higher level from which to decline.

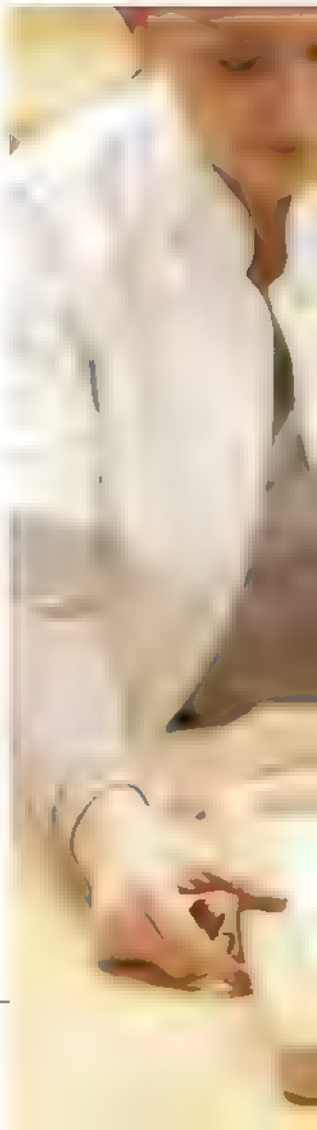
How, then, should you decide whether to spend time and/or money on brain-training workouts? Or should you just engage in lots of 'intellectual activities'?

Rather than ploughing through dense scientific literature, you can work it out for yourself by looking at how the brain functions. All brain fitness products sell themselves on one (true) fact about the organ: it changes with exercise. Neurons make new connections with each other, or strengthen existing ones, when they are stimulated. This phenomenon, called neural plasticity, is often likened to building a muscle. The brain is not a single 'muscle', however. It is made up of hundreds of interacting modules. Some of them look after bodily sensation and control, others are responsible for emotion, others deal with perception, memory, language and thinking. There are big bits (such as a whole lobe given over to vision) and sub-bits (like parts that deal with colour) and sub-sub-bits, right down to individual neurons that react to just one particular hue.

Exercising a module or sub-module will almost certainly improve its function, whatever that might be – it's called practise. So playing an instrument will help you make music, doing arithmetic will help you calculate, and hitting fast-moving objects will make you better at, well, hitting fast-moving objects.

Boosting one module or network of modules won't necessarily improve any others, though.

RIGHT CT scan section through the brain of a patient suffering from Alzheimer's disease. The condition causes widespread destruction (pink) of brain tissue (green) leading to shrinking of the brain



Mnemonic training helps to re-shape brain networks to aid memory

Indeed, it may even make other brain areas less efficient. One experiment found that stimulating a particular patch of brain tissue made people better at learning certain things, but made them worse at recalling similar things automatically. This is because the brain mechanisms that consciously encode new information are in a sort of seesaw relationship with the parts that unconsciously throw up stuff that is already learned. Quite a lot of the brain is constructed in this way.

To be generally competent therefore you need to exercise all your cognitive skills, together with shifting on demand from one to another – from conscious learning, say, to unconscious knowing – and doing it quickly. Some brain-training products try to help you do this by providing a suite of games, each of which exercises a different cognitive function, plus 'set-shifting' exercises and speedy reaction tests.

Even the broadest training systems can't replicate the deluge of challenges a person meets in 'real' life though. So someone with a young, healthy brain is likely to benefit most from being fully engaged in a wide variety of physically, emotionally, and intellectually

challenging pursuits.

It's different for older people because aging bodies (including brains) degenerate even if there is no diagnosable disease present. Cognitive training helps keep the mental wheels oiled and may make up, in some, for a lack of intellectual challenge post-retirement or reduction in physical and social activity.

The difference is even more marked for people whose brains have some particular problem or deficit. People recovering from stroke, which nearly always affects a specific part of the brain, benefit from therapy which helps rebuild the damaged area or trains up another area to take over. Appropriate computer training builds on conventional treatment, allowing people to help themselves rather than depending on formal therapy sessions.

Working on this principle, research teams are developing games designed to selectively boost activity in brain areas where damage is thought to be responsible for a wide range of mental health problems. Researchers at Cambridge University, for example, have developed an iPad-based exercise for people with memory problems that are part of schizophrenia.

Games are being designed to boost activity in brain areas where damage is responsible for mental health problems

"We've demonstrated that, in theory, a memory game can help where drugs have so far failed," says project member Professor Barbara Sahakian. "Because the game is interesting, even those patients with a general lack of motivation are spurred on to continue the training."

The big question, though, is whether brain training can prevent or reverse the terror of our age – Alzheimer's disease.

Alzheimer's is marked by loss of neural tissue, so it figures that brain exercises that build or strengthen it should help. In very early disease this seems to be the case, but in moderate and advanced cases there is very little evidence for benefit. In 2015, the Alzheimer's Society funded researchers from Kings College London to review the relevant evidence.

"It didn't show that it can delay or prevent the condition, but it does seem to help people with mild cognitive impairment to improve their memory, thinking and learning," says Dr Doug Brown, the then Director of Research and Development at the Alzheimer's Society. The Society is now testing its own online training product called GameChanger.

So, should you get back to that bubble-bursting? Probably no if you have something more stimulating to do, but yes if your memory is not what it was. And if you find it fun. **SF**

by **RITA CARTER** *Rita is a science writer and lecturer*

SUPERCHARGE YOUR BRAIN

What else can you do to keep your brain healthy and fire it up?

MEDITATE

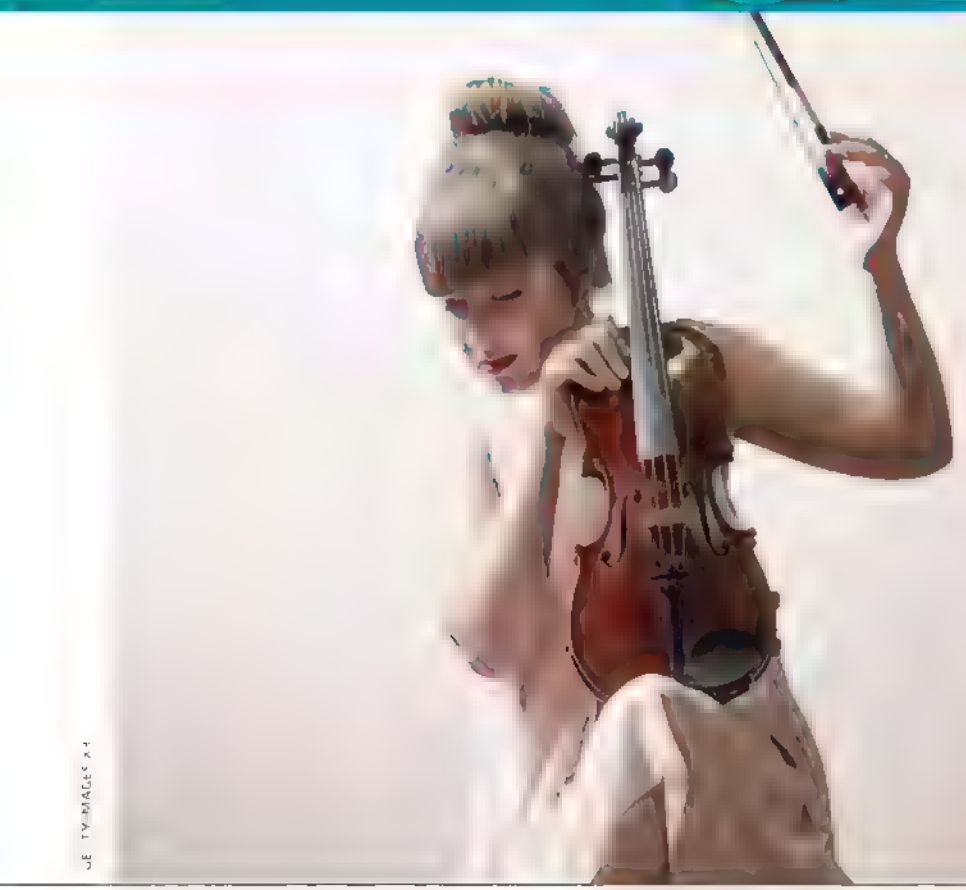
Mindfulness is the medication method of the

echniques, such as transcendental, Zen, Kundalini

hey each do something slightly different to the

brain, but they share a core effect – relaxation

EAT WELL



PLAY AN INSTRUMENT

Playing an instrument has been shown to improve or preserve overall cognitive ability, as it changes how the brain interprets and integrates a wide range of sensory information.

"Listening to and making music is not only an auditory experience; it's a multisensory and motor experience," says Gottfried Schlaug, director of the Music and Neuroimaging Laboratory at Harvard University. "Making music over a long period of time can change brain function and brain structure."

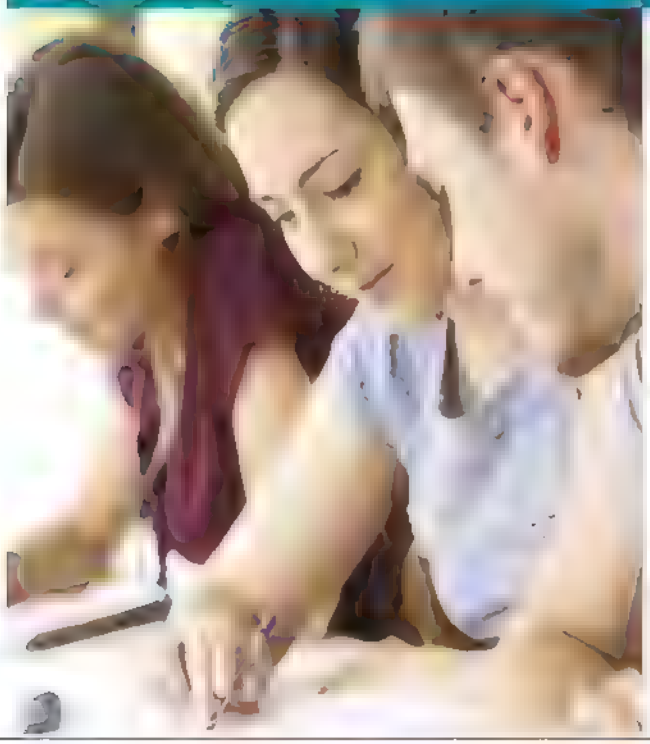
WIRE UP

Strapping electrodes to your skull to boost your brain power might sound a bit extreme, but transcranial direct-current stimulation (tDCS) is safe and said to be beneficial.

Hundreds of research papers have shown it can improve a wide variety of cognitive skills and relieve mood disorders such as depression. Its effects depend on precisely where the electrodes are placed on the head, though there is a 'sweet spot' (dorsolateral prefrontal cortex) which produces good effects on mood, memory and general cognition.

Around 10-20 minutes of tDCS a day seems to have modest, cumulative effects. However, some studies have found no effect at all, so don't expect a miracle.

There are several DIY devices on the market (such as Foc.us, Brain Driver.) These should not be confused with headsets like Muse, which measure brain activity but do not affect it



LEARN A LANGUAGE

Learning a language or practising a second one you've already learned has been shown to boost brain power.

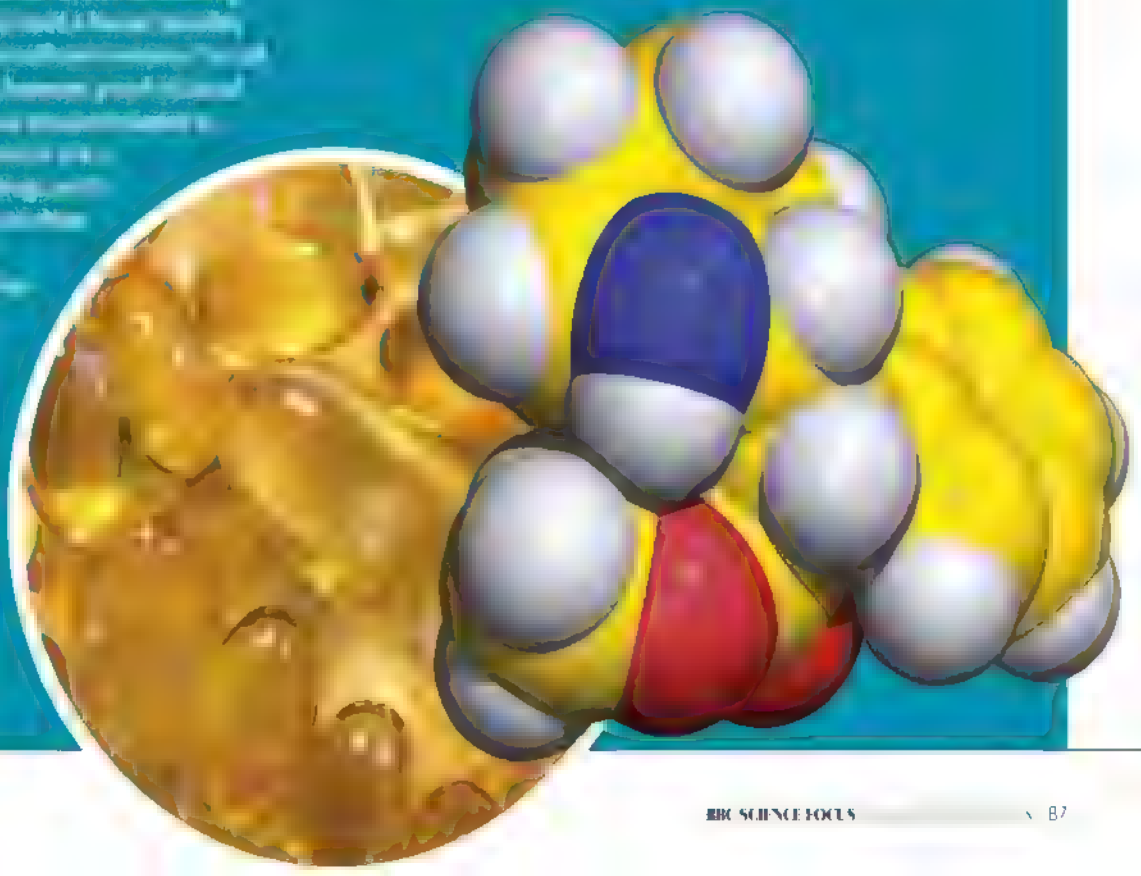
A team at the University of Edinburgh assessed mental alertness in a group of 33 students (aged 18-78) who undertook a one-week Scottish Gaelic course. After the course they were encouraged to practise their new language for five hours a week. At the end of the course, their attention was found to be better than comparison groups who had done other types of courses or no course at all, and nine months later those who had been practising had bumped up their attention span even more.

Lead researcher, Dr Thomas Bak of the School of Philosophy, Psychology and Language Sciences said the results confirm the cognitive benefits of language-learning: "I think there are three important messages from our study. Firstly, it is never too late to start a novel mental activity such as learning a new language. Secondly, even a short, intensive course can show beneficial effects on some cognitive functions. Thirdly, this effect can be maintained through practise."

USE WITH CAUTION

SUPPLEMENTS

SMART DRUGS



The NEUROSCIENCE *of* HAPPINESS

WHY IS YOUR LATEST BOOK CALLED *THE HAPPY BRAIN*. ANY REASON YOU CHOSE THIS TOPIC?

It's a bit of an elaborate back-story, but my first book *The Idiot Brain* went surprisingly well. But I hadn't planned on a first book, let alone a second one, so I had that very palpable difficult-second-album problem, and no idea what to write about. I spoke to lots of friends, collaborators, fellow writers and scientists asking what I should write about. They all gave me very different ideas. But the one thing that people kept saying when they kept sending me ideas was: 'Well, at the end of the day, you've just got to write about whatever makes you happy'. So I started taking that at absolute face value, looking at what makes you happy and why? And it just snowballed from there.

THERE'S LOTS OF WISHY-WASHY, SELF-HELP STUFF BEING BOUNDED AROUND ABOUT HOW TO ACHIEVE HAPPINESS. BUT IT'S ACTUALLY VERY DIFFICULT TO PIN DOWN, ISN'T IT?

That's one of the first things I realised. Because when you look up how to be happy, or the science behind happiness (and I use 'science' with air-quotes), it always comes down to 'there's these five tips' or 'you've got to train your brain to do this'. Some do say 'you've just got to boost your dopamine or your endorphin levels, and they use a fragment of science to give it some credibility. But we're not talking about a basic thing here. We're talking about a mental state of being. It's a complex emotion, it's a frame of mind, it's a sense of well-being, so how you define happiness can be really varied and complicated. The idea there is one simple trick is misleading. It's an oversimplification.

● If I'm being generous, I think a lot of the time it's a misunderstanding of how complex happiness is. One thing I tried to look at in the book is what does the actual evidence say?

IN THE BOOK YOU SAY THAT THE NEUROSCIENCE OF HAPPINESS IS DIFFICULT TO STUDY BECAUSE THERE'S NO 'HAPPINESS-LOBE' IN THE BRAIN...

I had initial ideas to try and track down a happiness-lobe using a fMRI scanner – the neuroscientist stock in trade. But it's not as simple as the notion that the brain works in a straight-forward, modular way. You see so many studies saying 'this is the bit of the brain for buying Apple products', 'this is the bit for voting preferences', 'this is the bit for belief in certain religions'. But that's not how it works at all. That's massively extrapolating from basic raw data. With something as complex as happiness, it's not one thing, it's more an umbrella term for different experiences, sensations and moods. You're happy if you're in a state of euphoria, but you can also be content and relaxed – those are also states of happiness.

TELL ME ABOUT THE ROLE OF CHEMICALS, SUCH AS OXYTOCIN, SEROTONIN AND DOPAMINE, IN HAPPINESS...

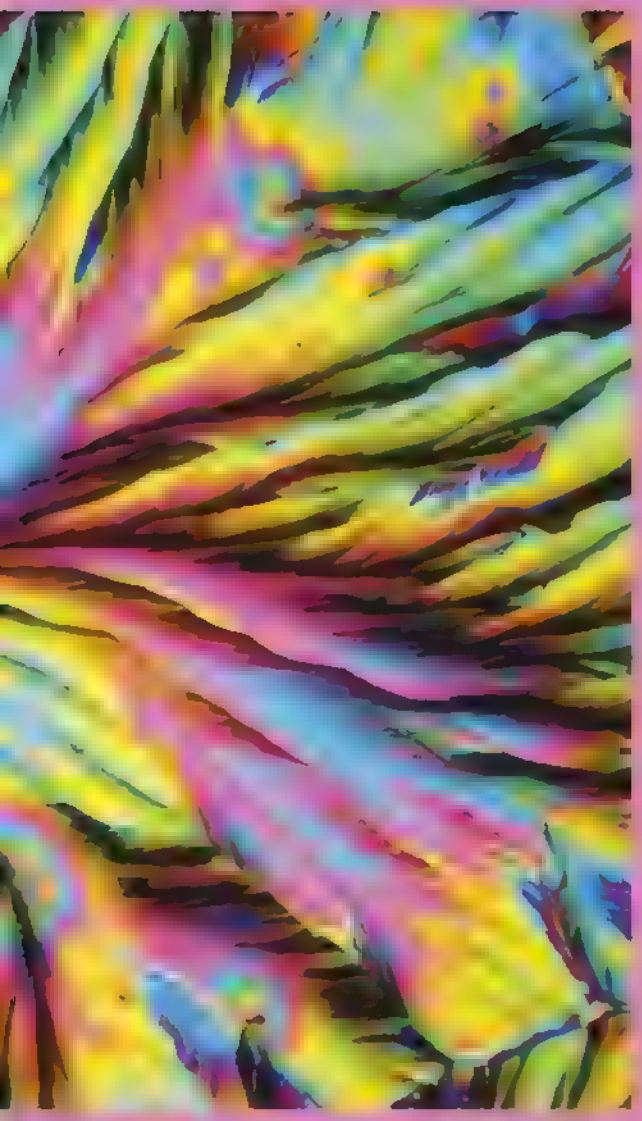
The brain uses neurotransmitters like language uses letters. There are different combinations and different words can be constructed in different ways. But that doesn't necessarily mean that the letters themselves are intrinsically part of that. I think the example I use is that if you take the word 'love', half of it is the letters O and E, so O and E are technically then the most romantic vowels. So if you want to chat someone up, you should use as many of them as possible. But 'hellooooooo, I love yooooou eeeee' isn't a way to charm someone. It's terrifying. So just because dopamine is used in happiness doesn't mean it is intrinsic. It's a tool – part of the apparatus. It's like saying, 'A house is made of bricks', which is true, but if you've got a pile of bricks, you don't have a house. You have a pile of bricks.

SOCIAL INTERACTION SEEMS TO BE KEY TO WHAT MAKES US HAPPY...

Generally, yes. One thing that kept coming up a lot, was the importance of other people – our social interactions. A lot of the main theories [claim that the reason] why humans became so much more intelligent than our primate cousins is that we are the most social primates. We depend on the group far more than any other species tends to. It allowed us to dominate the environment, but when you dominate the environment as part of a group, then survival in the group becomes the driving factor of evolution. Not survival in the wild.

ABOVE Dopamine crystals illuminised by polarised light

"You can be happy without other people, but having others around makes it more likely. It comes down to the basic things like sexual interaction"



ABOVE Owning your own home can make you happier, as renters often have no freedom to make a place their own

And being a successful part of a social group is a lot more cognitively complex than just running down prey animals. So, we've evolved greater intelligence. But that suggests that if our interactions and socialisations are a big driver in intelligence, then the brain would have a lot of parts dedicated to that. And it does, it seems. So happiness being an emotion or mood means it only exists in the context of other people. Like the sense of guilt and the idea that you've wronged someone. Without other people, that doesn't make any sense. You can be happy without other people, but having other people around makes it more likely. Even down to the basic raw things like sexual interaction. You need someone else for that.

WHAT'S THE PHI COMPLEX?

It's essentially a network of neurons which facilitate communications. When a conversation is happening, our phi complex and the phi complex of the person we're talking to sync up. It's sort of like the neurological representation of the conversation itself. A bit like two people playing the same game [together] yet remotely via the internet. The same game is happening on both consoles but from a different perspective.

HOW DOES SOMEONE'S HOME AFFECT THEIR HAPPINESS?

We clearly have this deep-seated instinct to make a home. Most have this underlying instinct to form a safe place in which to reside. Even creatures like elephants have territories. Maybe because there's so much that we do as biological organisms that leaves us vulnerable. We need to sleep, excrete, eat, reproduce and look after young. It's a lot easier to do all these things when you have a safe environment which you recognise as familiar and are able to map out accurately. So a typical home contains so many things which are linked to our fundamental sense of safety, which makes us happy.

But we're not just living in a home for a sense of safety. We make it our own and put our own stamp on it if we can. Some people in rental accommodation have far more strict rules [because of their landlords], and they tend to have a lot less happiness in their home because of that.

DOES SUCCESS MAKE YOU HAPPY?

According to a lot of research, much of human

ALAMY GETTY IMAGES

ABOVE Falling over in the mud is funny because it's so harmless

RIGHT Chimps laugh when tickled because it's the most primitive form of laughter

motivation is goal directed. We want to be successful, admired, secure, liked, have high-status. These are all fundamental long-term goals. If you're working towards a goal that you have in your head it makes you happy because you are working towards that goal. Jobs which detract from that tend to make you less happy. So, if you want to be a rock star and you've got a really demanding job that won't let you go home to rehearse, it can be really stressful because both the work is hard, and you're not fulfilling what ambitions you have.

But I talked to the entrepreneur Kevin Green. He made me realise that people who achieve their ambitions, can be happier. But we're not finite creatures. We don't just stop when we've achieved a goal. We wake up the next morning and life carries on. And the brain doesn't like that. If you work towards a goal that you've had in mind for years and then achieve it, that's great. But that doesn't work forever. The brain isn't static. It's constantly changing, it constantly craves new things, new experiences and a sense that we are achieving still, so then we need a new goal, or something else to work on. If you want to be a rich person, then how rich is enough?

CAN ANYONE BE HAPPY?

Based on what I found out, I think everyone has the underlying mechanisms inherent in their brain to experience happiness – of course, barring major traumas. But it takes a lot of time, effort and practise. So some people will be less inclined towards being happy and are predisposed to finding the negative in everything. Genetics plays a part, but it depends on your background and upbringing. I know twins who are very different people, yet they grew up in a similar environment, but as they matured and went their separate paths they followed different outcomes and different outlooks on life.

CAN HAPPINESS EVER HAVE A DOWNSIDE?

Yes. Although I found a stat that happy employees are 37 per cent more productive, so if [a business has] 100 happy employees, they're doing the work of 137 for no extra cost. But a lot of evidence suggests that people who are happy tend to be more selfish – and more concerned with their own happiness than that of others. You could argue that's a chicken and egg situation. Are they happy because they're selfish? Because they look after themselves more than anyone else? Do they put themselves first, and therefore they've achieved their own happiness as a result?

And people who are persistently happy can often be more devastated when something goes badly wrong. Some evidence suggests that people who have a predisposition to be happy will be made a lot more unhappy by set-backs, because they're not used to it. They don't have the ability to cope with it.

YOU'RE ALSO A COMEDIAN. TELL ME ABOUT THE SCIENCE OF LAUGHTER...

We all have this mental model of how the world works. When things violate that, they cause a sense of incongruity. Normally, that causes a sense of stress or danger, because the

ALAMY GETTY IMAGES

"Uncertainty makes us unhappy. But when it can be shown to be harmless, then it becomes pleasurable. That's what jokes do"

brain doesn't like uncertainty. Uncertainty makes us unhappy. But when it can be shown to be harmless, then it becomes pleasurable. So, you experience this release of tension. That's one theory. Or it could be just a case of experience and a sense of reward, because an uncertain thing occurred, but it was resolved with no danger and, therefore, well done, have a reward for that.

That's sort of what jokes do. They set up a sense of incongruousness and then resolve it in a harmless way. Slapstick will do that. If someone falls over and breaks their neck, that's horrific. But if someone falls over and lands in some mud and they're fine, but they look ridiculous, that's good. They've lowered their status, you can feel a bit more superior as a result. It's the social element again.

It's very hard to make people laugh when they're in a fMRI scanner. But what data suggests is that there's a hub in the middle of several lobes in the brain, which oversees all the sensory inputs, because you can laugh at any sensory normality – a funny sight or sound. And you laugh when tickled, which is the most primitive form of laughter. That's why you can make rats and chimps laugh by tickling them. Laughter actually predates humanity. There's a massive social element to laughter. **SF**

THE POWER OF LAZINESS

LAZINESS GETS A BAD RAP. WE'RE CONSTANTLY BEING TOLD TO DO MORE, WORK HARDER AND MAXIMISE PRODUCTIVITY. BUT THERE'S ANOTHER SIDE TO THE STORY, AS BEING LAZY CAN BE GOOD FOR BOTH OUR PHYSICAL AND MENTAL HEALTH... PLUS, IT'S FUNDAMENTAL TO THE WAY WE THINK

GETTY IMAGES

ACHIEVE MORE BY WORKING LESS

Breaks and naps are no obstacle to a productive day

words by ANDY RIDGWAY

The logic sounds simple: if you work more hours you'll get more done. But studies consistently show that our brains are a bit like muscles in that the more we use them, the more tired they get. So short, sharp stints of work with *plenty* of breaks is the way to go.

According to a study by software company Draugiem Group, the ideal work-rest balance is 52-minute working sprints with 17-minute breaks. It reached this conclusion by analysing data from productivity app DeskTime. Workers who achieved the most were the ones who tended to work in this pattern.

As well as taking more breaks, getting some daytime shut-eye can help. Researchers at the University of Pennsylvania found that people who napped for an hour at lunchtime performed better in recall tests and tests that involved solving maths problems than those who didn't nap, as a little doze gives the brain a chance to recharge.

The key is to keep naps short to avoid sleep inertia, which is a groggy state sometimes experienced upon waking – although a recent review has highlighted that even a short nap can sometimes lead to this undesirable state. It is important that we take time to fully wake up after a snooze, in order to ensure a safe transition back into a hectic working day.

Short, sharp stints of work with plenty of breaks is the way to go

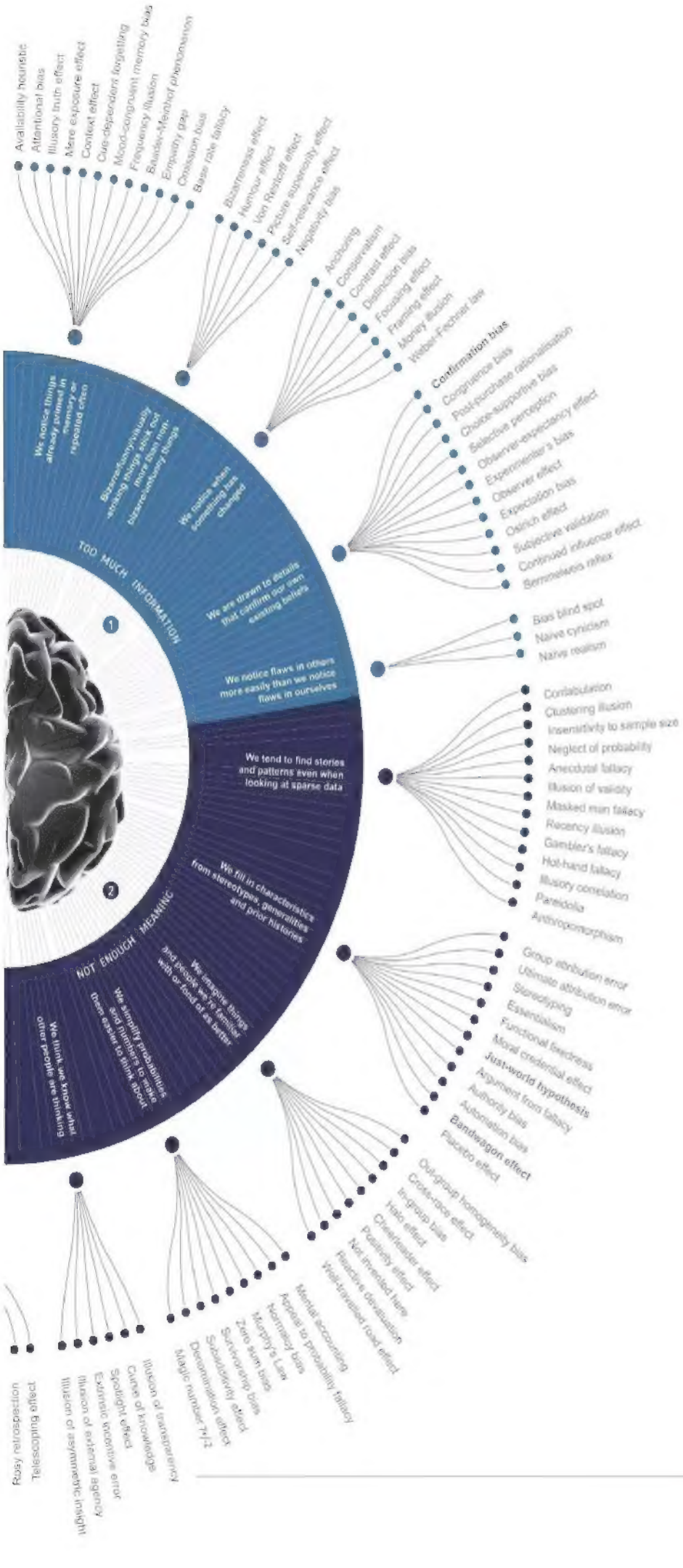
THE LAZY BRAIN

Our brains are incredible machines, but they're also somewhat lazy. In order to cope with the vast amounts of information streaming through our senses, our brains have evolved to act as quickly and efficiently as possible – saving both time and energy. But this means that they often get things wrong, as shown in this diagram collecting together all of our common errors in judgment documented by psychologists. These are known as 'cognitive biases'. They can be overcome... but doing so takes effort

words by DEAN BURNETT
infographic by PHIL ELLIS

This infographic is based on work by Buster Benson, Product Manager at Patreon and digital designer John Manoogian I

by DEAN BURNETT *Dean is a neuroscientist, science writer and comedian.*
and ANDY RIDGWAY *Andy is a science writer and lecturer*



Human cognition is riddled with biases and shortcuts, most of which exist to give us a fighting chance of keeping up with events. Essentially, these biases have arisen to tackle four separate, but interrelated, problems that we experience on a daily basis (credit to Buster Benson here for doing the hard work and categorising all these biases).

1 Sometimes there's just too much information in the world around us, so the brain prioritises the new and interesting stuff over the familiar and mundane, even if the latter is contextually more important, hence we sometimes filter out useful information.

2 Sometimes we can handle all the information but we can't discern what it means, so the brain falls back on existing assumptions and stereotypes to cut through the uncertainty, even if these assumptions are invalid, or actively harmful.

3 Impressive as they are, all neurological processes take time, and the more complex and rational they are, the longer they take. Sadly, the world doesn't just pause and let us figure things out thoroughly, so our brains use 'instinct' and other emotional processes to make timely decisions. Unfortunately, these snap decisions can also be inaccurate and counterproductive.

4 Our brain has copious memory storage, but it can't remember everything. How does it know which memories are relevant or useful? Generally, memories are prioritised according to which are more stimulating or emotional. Unfortunately, real-world decisions often require logic and reason, so basing decisions on your most emotional experiences is often unhelpful.

Knowing that all of these biases can affect your thinking is half the battle – familiarise yourself with the 20 categories shown on the inner ring. Once you're aware of these cognitive shortcuts, you can potentially learn to compensate for them. Your immediate responses may be riddled with problems, but your second or third attempts to understand something need not be. SF

IMPROVE YOUR MOOD IN WINTER

Find excuses to get out of the house if you want to fend off the winter blues

words by MICHAEL MOSLEY

Winter is miserable. The days are cold and damp and, once Christmas is over, there's little to look forward to.

A study published a few years ago in the journal *Epidemiology* showed striking evidence that winter casts a malign shadow. By inspecting hospital records between 1995 and 2012, Danish researchers discovered that the number of people diagnosed with moderate to severe depression jumps by 11 per cent every November.

One of the researchers, Dr Søren Dinesen Østergaard, thinks it is linked to the fact that Danish clocks go back an hour at the end of October, as they do in the UK. So in his view this November surge is likely to be psychological rather than physical.

He may be onto something, but I also think there are physiological reasons why we get gloomier in winter. A couple of years ago I was diagnosed with seasonal affective disorder (SAD). I'm not bad enough to need antidepressants or psychotherapy, but last year I bought a light box, which sits on my desk, bathing me in 10,000 lux of bright white light for an hour each day. I also take the dog on early walks since exercise outdoors in the morning seems to be effective at reducing the impact of SAD. And it all seems to be working.

If you suffer from winter gloom, you could try changing what you eat. In an Australian study, 67 patients with moderate or severe depression, were randomly allocated to either a Mediterranean-style diet (more fruit and veg, and red wine instead of beer or spirits) or 'social support'. After 12 weeks 32 per cent of those on the Med diet went into remission compared with eight per cent in the control group. Those who stuck closest to the diet saw the biggest improvement in mood.

> **"Exercise outdoors seems to reduce the impact of SAD"**

Other mood enhancers we have tested on *Trust Me, I'm A Doctor* include yoga, gardening and mindfulness. In 2017, we ran an eight-week experiment with Prof Angela Clow of Westminster University, in which we split 68 volunteers into four groups. One group was asked to join Green Gym, a charity that encourages people to practise gardening. A second group was sent to a weekly yoga class, while a third was prescribed a daily dose of mindfulness. We also had a control group, who were asked to continue as normal.

Clow and her team asked the volunteers to fill in questionnaires before and after, and also measured their levels of the stress hormone cortisol. After eight weeks, the gardening and the yoga groups had both improved compared with the controls, but mindfulness came out on top. What was interesting was the wide range of responses: although some people got a lot of benefit from these interventions, others got none at all. It turned out that the best predictor of whether you would benefit or not was whether you enjoyed it. And on that note, I'm off to walk my dog again. **SF**

BBC TWO

by DR MICHAEL MOSLEY

Michael is a science writer and presents ***Trust Me, I'm A Doctor.***

ILLUSTRATION | JOE WALDRON

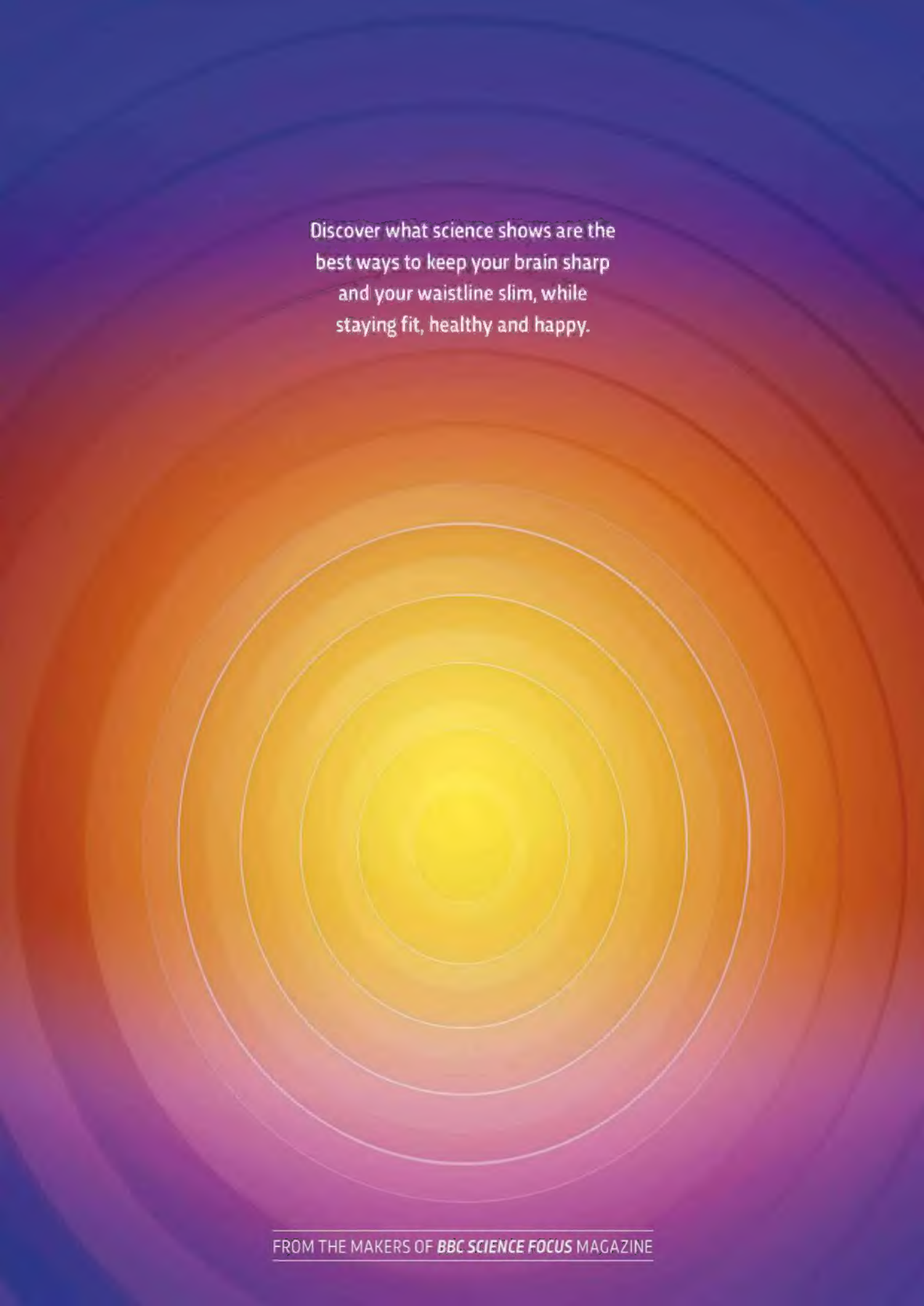
Into the fold

These long, bumpy filaments are the hair-like projections which line the small intestine, known as villi. The extra surface area they provide allows a greater amount of space for digestive function.

Inside the epithelium (pink) are goblet cells (stained blue), which secrete mucus to lubricate food and prevent self-digestion. The centre of each villus, the lamina propria, contains the blood supply that transports the products of digestion.

GETTY IMAGES

Discover what science shows are the best ways to keep your brain sharp and your waistline slim, while staying fit, healthy and happy.



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